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MM/T PROGRAM FOR THREE COLOR LIGHT EMITTING DIODE DISPLAY MODUL--ETC(U)

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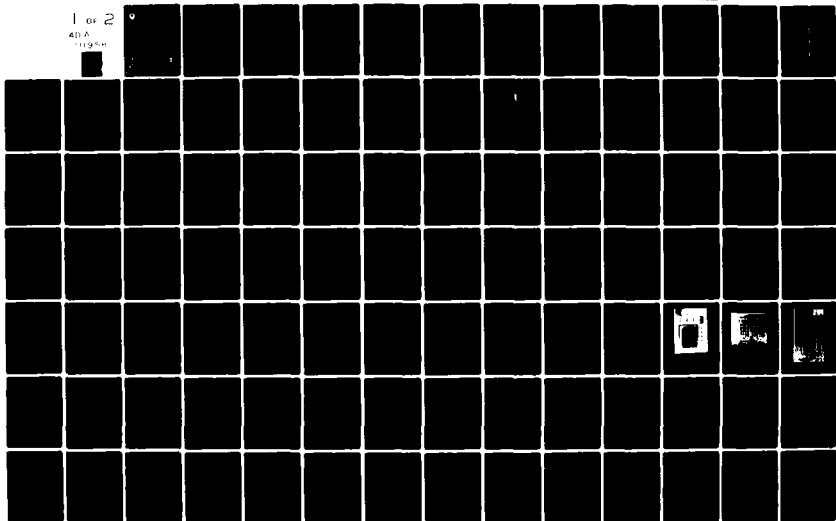
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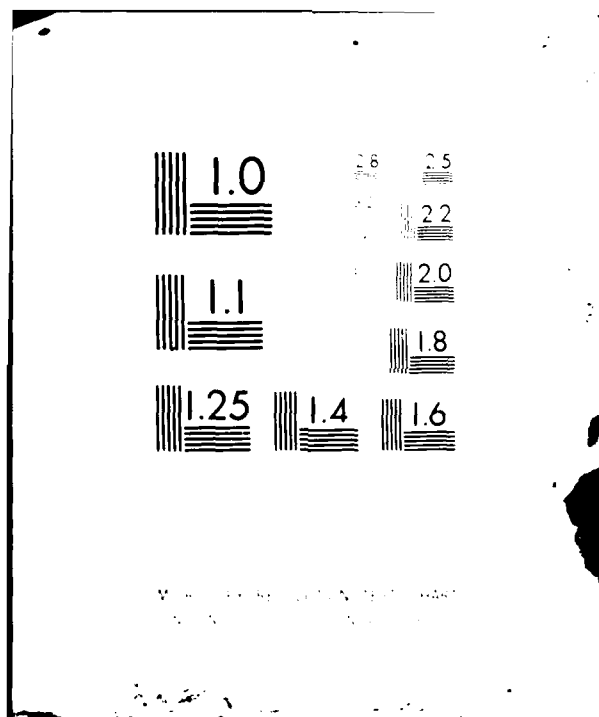
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Research and Development Technical Report

**MM & T PROGRAM FOR THREE
COLOR LIGHT EMITTING DIODE
DISPLAY MODULES**

ADA 111 958

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are included. Problems involving the quality of procured light emitting diodes and collimators are discussed, along with actions which are being taken to resolve them.

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PURPOSE

The purpose of this contract is to develop an automatic manufacturing production capability for the production and testing of a Three Color Light Emitting Diode (LED) panel.

This purpose can be broken down into the following tasks:

1. Development and acquisition of automatic die attach and lead bond machines which can demonstrate a capability of producing 750 LED panels per month by using additional machines.
2. Develop multiple sources of supply for the LEDs in a form which will allow utilization of the automatic die attach equipment to its greatest potential relative to time consumption for the attachment of the LEDs.
3. Improve the encapsulation concept and its associated tooling in an attempt to reduce cost and to make it producible at the manufacturing rate delineated in task No. 1 above.
4. Establish a test system which will have the capability of testing both the green and red LED's upon receipt from vendors to verify that they meet the illuminance requirements. This test system shall also be utilized to test the LED panel after die attach and lead bond, prior to encapsulation, and at the final test after all other operations are completed.

1. NARRATIVE AND DATA

1.1 DEVICE

1.1.1 Structure

As indicated in earlier documentation related to this project, the basic circuit to be discussed herein is a light emitting diode (LED) display (MMT-799938) consisting of 2,048 individual picture elements (pixels) to be placed in a matrix of 64 rows and 32 columns. The center-to-center distance of the individual elements is expected to be 0.045 in. Each element is to have a green diode and a red diode, thereby making it a three-color display. Red and green colors are obtained individually by turning on just one diode and, since light emission is additive in this case, turning on both diodes in a picture element at the same time results in a yellow color. A collimator with reflecting side walls is to be affixed to the front side of the display in such a manner that each picture element is individually defined and physically separated from the neighboring picture element. The light emitted from a picture element should be largely collimated in the vertical direction. When a map is placed on top of the display, the picture elements can be seen through the map with no appreciable diffusion (divergence) of light from or to the neighboring elements. The total dimensions of a given display circuit would be 2.88 in. X 1.44 in. Ultimately a large number of these displays are to be assembled together on a single display board. This requires an additional constraint on the display; namely, the picture elements at the edge of a given display circuit have to maintain the 0.045-in. distance from the neighboring picture element of the next display board with reasonable accuracy. Otherwise there would be noticeable discrepancies in the overall image presented on the board. With due consideration to the requirements described above, one of the first tasks performed at TM in connection with this project was designing and drafting of the outline drawing (top assembly) of the diode display (Figure 1). Inspection of this outline drawing readily reveals the close dimensional tolerances involved in the manufacture of the display.

1.1.2 Problem Areas

It is well known that Teledyne Microelectronics (TM) entered the display business through a contact with Litton involving the manufacture of ten complete display modules with 0.045 in. pixels and ten additional modules with 0.050-in. pixels. The modules also included the drive electronics required for external system control of the displays. Experience gained during the Litton project has been highly useful in performing the present contract because basically the displays under consideration from both projects are identical. Since the final version of displays delivered to Litton was more or less a starting point for the present displays, the next few sections are essentially devoted to the comparison between the two displays and a detailed analysis of modifications made to the basic Litton display to improve its producibility and quality.

1.1.2.1 Ceramic Substrate - The ceramic substrate utilized in the previous display had outside dimensions of 2.875 in. X 1.435 in. X .050 in. with all six sides ground. Since the front (diode) side of the display had to communicate with the rest of the world through some type of artwork on the back side (please note that the front surface is entirely covered by diodes and X-Y lines with no room left for external leads and other encumbrances), the ceramic had to have wraparound metallization along the edges to communicate with the back side or it had to have judiciously placed plated thru-holes to do the same. The plated thru-hole concept proved to be extremely expensive; therefore, the thick film wraparound concept was embraced because the technology for screen printing and firing wraparound conductors has been well proven for several years. It turned out, however, that the wraparounds made this way were subject to handling damage, not only during the potting and grinding operation, but also during testing. There were several instances of individual conductors getting badly damaged and having to be repaired by using epoxy or welded ribbons.

1.1.2.2 Artwork - There were two basic problems with the previous artwork:

1. The top circuit artwork involving three layers of conductor and strips of dielectric separating individual layers did not have surfaces flat enough for the placement of dice and placement of bonds. Due to this, the dice after placement tended to go to some equilibrium location which was away from the original placement location (Figure 2). This caused slight loss of placement accuracy and made the top bonding surfaces of dice non-horizontal, thereby making the lead bonding parameters more critical.
2. Associated with the artwork was the backside metallization pattern. Due to the usage of platinum-gold thick film on both layers of the two-layer metallization on the back and due to the overall length-to-width ratio of the conductors, the resistance between the edge wraparound and the pad to be soldered to the drive electronics circuit was too high. The nature of this problem will become clearer when the appropriate solution is discussed in the next section.

1.1.2.3 Collimator Design - Problems were encountered during the usage of previously designed collimators made by Crest Molded Products of Monrovia, California, and subsequently processed by Ward Engineering of Glendale, California, and General Optics of Newbury Park, California. The collimators were generally warped, which made it very difficult to place them on the die and lead-bonded substrate without some possibility of damage. They were also dimensionally incorrect in some instances. This further reduced the error margin available for the placement of dice.

1.1.2.4 Optoelectronic Encapsulant - The encapsulant used on the Litton display project was not capable of withstanding greater than 100°C temperatures. This made rework of the finally assembled module

NOTE: For simplicity, the row metallization is not shown.

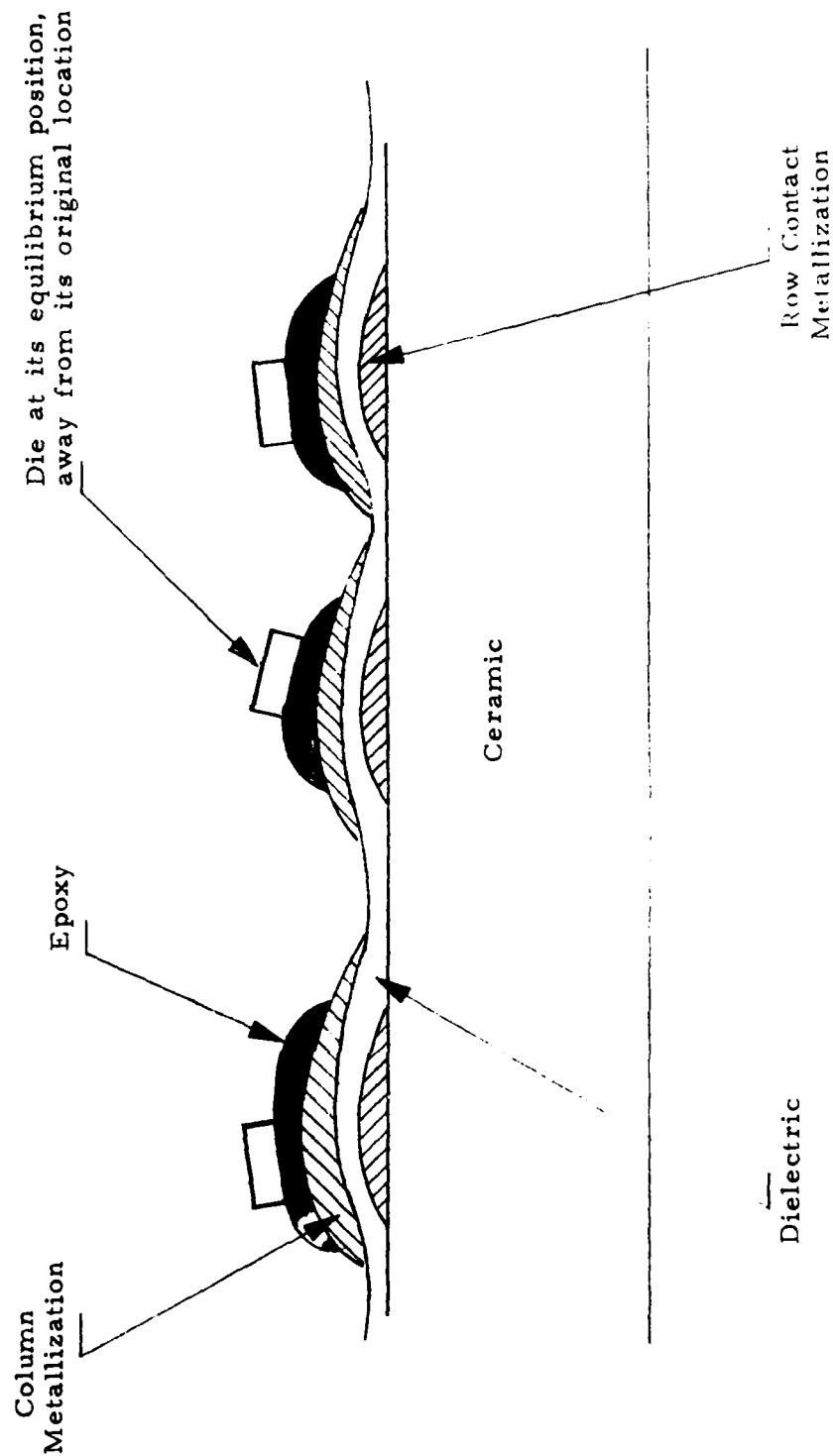


FIGURE 2. Cross section of a typical display hybrid before lens attach.

impractical. Although rework was performed on some of the finished modules, it had to be done very carefully to avoid undue temperature excursions.

1.1.2.5 Material Costs - Since all conductor materials used on the present display design are either gold or platinum-gold thick film materials, the cost of these materials forms a substantial percentage of the overall cost of the display. Even though this contract does not include a study of low-cost thick film materials, it is worth noting that substitution of gold with silver conductors will reduce precious metal costs by a factor of 5 or more.

1.1.3 Resolution of Problems

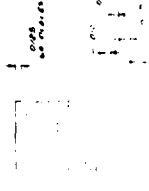
1.1.3.1 Ceramic Substrate - To alleviate the problem of handling damage on the wraparounds, a ceramic with notches was designed (Figure 3). In this design, the wraparounds go through the notches to the other side. Either a thin film evaporation process with subsequent grinding of the outside surface or a thick film process with a screen can be used to fill up the troughs in the notched ceramic. The final decision will be made after experimenting with both processes. With the wraparound conductors in the troughs, the handling damage would be eliminated and the grinding process to get the final display down to 2.88 in. X 1.44 in. or less would be simplified considerably. In the previous design a grinding error of even one mil from one end to the other could prove disastrous because the conductors, being much softer than the ceramic, would grind away at a much faster rate. Careful calculations for individual dimensions had to be made during the design of the ceramic to fit all the needed conductors for 64 rows and 64 columns on the top surface. It should be noted that the notch design is not symmetrical. This is because of the peculiar die placement needed to keep the same .045 in. pitch from display to display. The notches are .003 in. deep, which is considered an optimum depth to avoid handling damage and at the same time permit deposition of conductive material in the notches with ease. Deeper notches were not feasible because that would have reduced the clearance between the edge and the closest conductor to unacceptable levels.

The finished ceramic drawing was sent to six prospective suppliers for bids. Analysis of the returned quotes enabled TM to select two suppliers; namely, Spectrum Ceramics, Inc. and Kyocera International, Inc. Unless new developments take place, one of these suppliers will furnish the ceramics. It is noted that these ceramics have to be more complex than the ones used for ordinary hybrids. This ceramic requires all six sides to be ground to extremely close tolerances. Normal ceramic tolerance for hybrids is $\pm 1\%$ but in this case the final dimensions have to be held to $^{+.000}_{-.002}$ " because of the close tolerance required on the display pixel center-to-center distance. This results in all dimensions being closely specified with no appreciable cumulative tolerance.

- 1.1.3.2 Artwork - Changes were made in the basic artwork to solve the problems experienced during Litton's build cycle. The artwork drawings are presented in Figures 4 through 8 to indicate the details of the new design. The artwork has three front layers. One of the layers is basically used to transfer the row connections to the long sides by connecting to the rows one by one along a diagonal on the ceramic and having a conductor from that point going to the appropriate edge wraparound. Previously, just dielectric strips were used to separate this layer from the subsequent column and row layers. This caused the problem described earlier pertaining to non-flat surfaces. It also created conductor shorts in a few instances because the thick film gold had a tendency to spread out as shown in Figure 9. Both of these problems have been solved in the new artwork by utilizing a continuous layer of dielectric and 64 vias along the diagonal to connect the row conductors. The backside metallization has also been improved to reduce line resistance. First, pure gold conductors will be used for the bottom layer to reduce resistance. Second, the length of the platinum-gold conductor has been decreased and the width has been increased to derive a net reduction in the number of squares. With these changes, the overall line resistance is expected to go down from about 2 ohms to 800 milliohms.



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FIGURE 1. Artwork, 2nd Metal Layer, Frontside

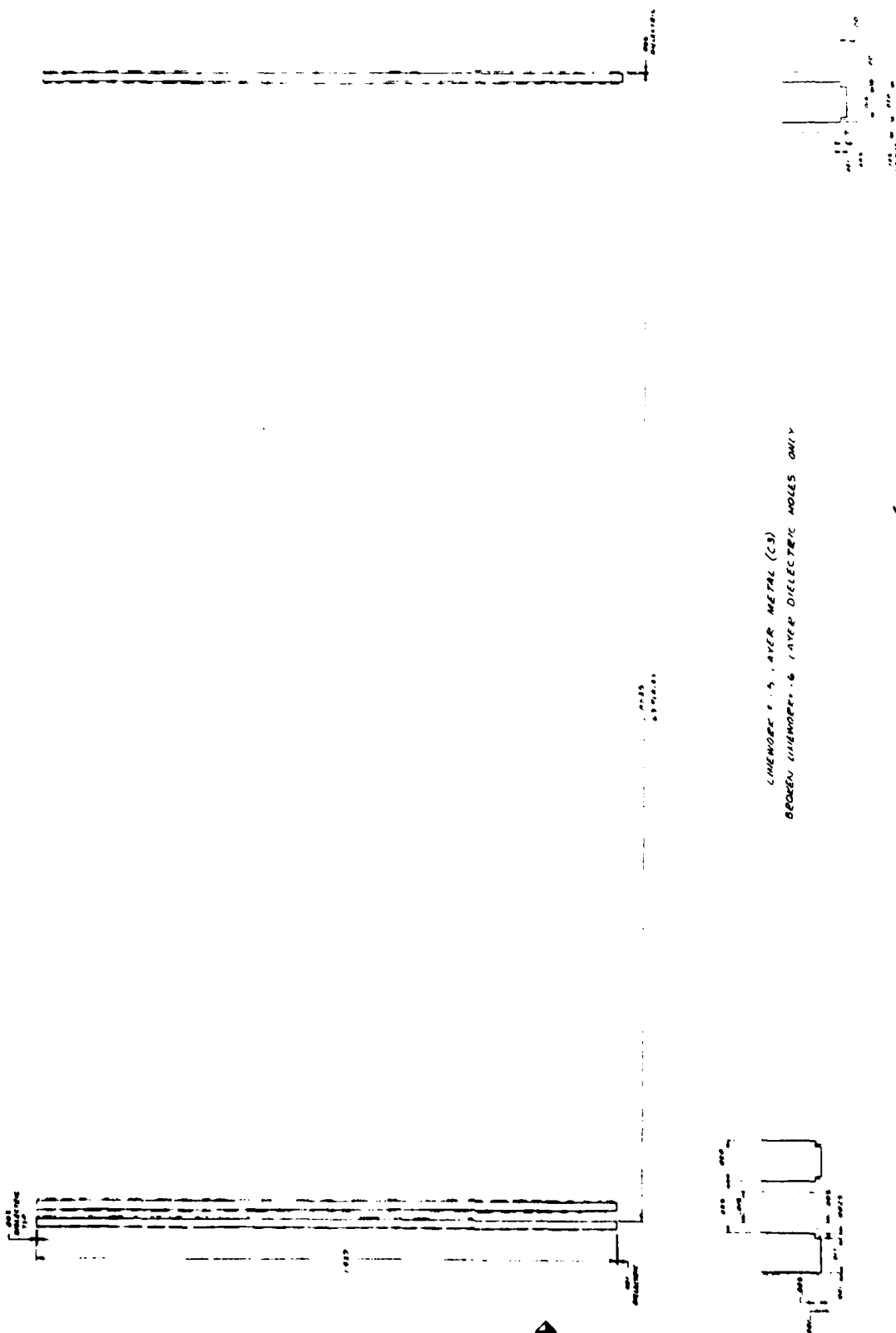
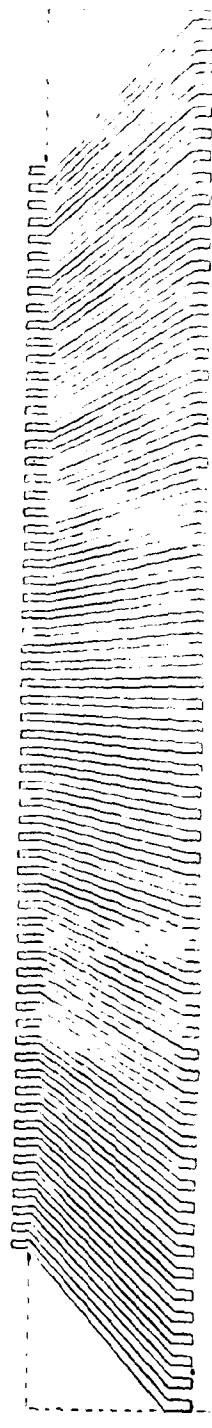
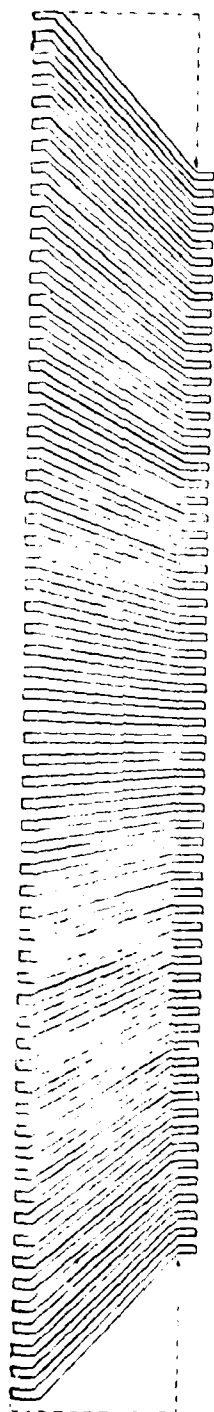
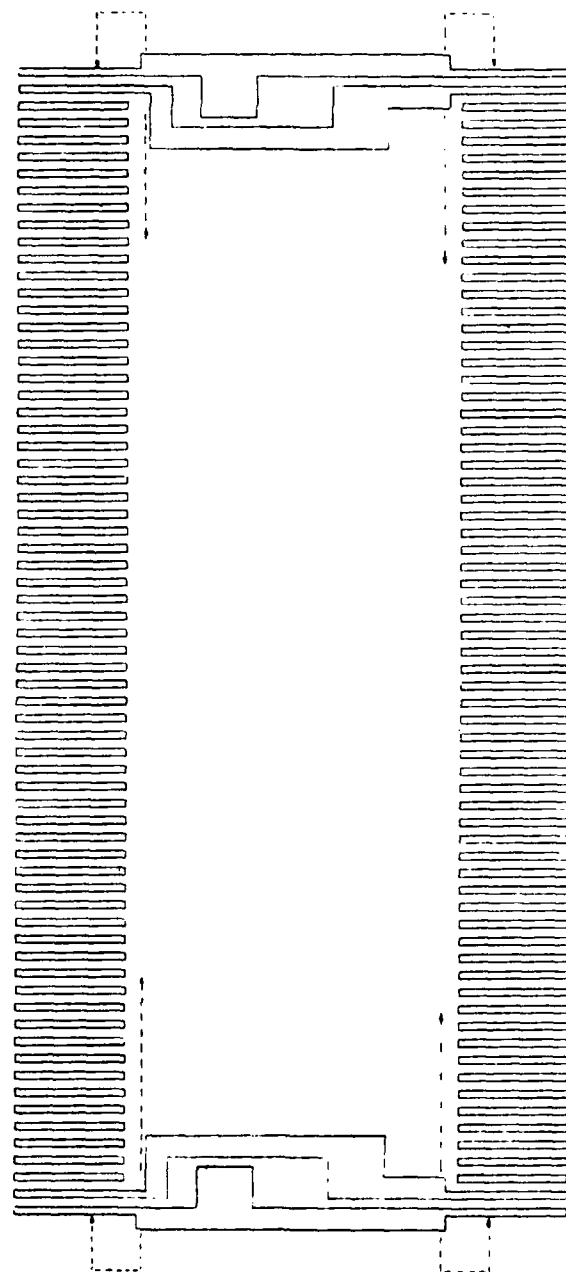


FIGURE 6. Artwork, 3rd Metal Layer, Frontside



CHROMIUM-7 LAYER METAL (10)
 HASN CHROMIUM-7 LAYER COLLECTOR METALS ONLY
 SECTION 1000000

FIGURE 7. Artwork, 1st Metal Layer, Backside



9 LAYER METAL (CS)
 BROKEN LINES IN 11 LAYER DIELECTRIC HOLES ONLY
 ALL OTHERS ARE IN 9

FIGURE 8. Artwork, 2nd Metal Layer, Backside



FIGURE 9. Row Conductor Detail

1.1.3.3 Collimator Design - New materials such as polyphenyl sulfides and compression moldable epoxies are being investigated for their thermal and chemical properties. Ultimately a material with very low temperature coefficient of expansion, sufficient strength and good machinability is needed to suit the collimator requirements. In terms of minor design changes the guide holes in the collimator will be changed to a hole and a slot. All dimensions will be referenced from the hole which goes into the guide pin of the holding fixture for potting and grinding. The slot will be useful for taking up the warpage in the collimator.

1.1.3.4 Optoelectronic Encapsulant - A new optoelectronic encapsulant made by Hysol, Type OS1000, is being tested at this time as a replacement for the earlier material. This material can be cured at 170°C and can withstand 150°C temperatures for a long period of time. Initial tests on displays with collimators have been quite satisfactory. One additional advantage of this material has been its slightly higher hardness, which makes it much easier to grind to a perfect finish. A test on lead bond reliability of this material is under way. The test procedure being used is as follows:

1. Fifteen lead bond test patterns have been bonded with 1-mil gold wire on a Hughes 1460 automatic thermosonic bonder. Each test pattern has 400 lead bonds, making a total sample of 6,000 bonds. These test patterns have been bonded in such a way that a single electrical continuity test on the pattern suffices to show that all bonds are intact. After lead bonding and initial test, a collimator was attached and the bonds were encapsulated by using Hysol OS1000 optoelectronic liquid encapsulant.
2. Continuity tests were performed after initial attach. After 24 hours at 150°C and after 10 thermal cycles from +85°C to -10°C, plus 10 additional cycles from -55°C to 125°C, no bond failures appeared. After continued heat soak at 150°C beyond that point, the material discolored but the bonds did not fail. This provides strong testimony to the reliability of the material, considering the fact that 150°C storage goes well beyond the maximum operational temperature for the display.

1.1.4 Conclusions

Considering the changes described in the foregoing which were finalized and others which, in many ways, are being finalized after a great deal of research into every aspect of the display design, it can be concluded that the new device will be structurally superior, more reliable and easier to produce. The notched ceramic design will eliminate handling damage, changes in the artwork will make the display substrate easier to produce, and changes in the collimator and optoelectronic encapsulant in addition to the artwork will make the design more reliable and, even more important, amenable to standard rework. In general, work in the last six months has shown for the first time that large quantities of such displays can be produced economically at reasonable rates of production.

1.2 PROCESS, EQUIPMENT, AND TOOLING

1.2.1 Processes

1.2.1.1 Purpose of Each Step

This section will be utilized to describe the processes and equipment used for the manufacture of the display circuits, problems entailed in the present build cycle, and the resolutions of the problems. The format of this section will be similar to the previous one in that the Litton build cycle used previously will be compared with the one visualized for the MM&T contract. Initially the purpose of each step in the flowcharts will be described. Latter parts of this section will deal with the problem areas and subsequent resolutions.

1.2.1.1 Thick Film Processes - The thick film flowchart used for the Litton program is shown in Appendix A. The flowchart used on the MM&T contract will be basically the same. The only change being considered at present would be in the edge wraparound steps which may be replaced by thin film operations, depending on ease of processing. There will

also be a via layer between first and second dielectric after first conductor. The sequence of processes such as print/fire first conductor is shown in the flowchart with a section for incoming and outgoing quantities. Document numbers shown in the second column are all standard TM documents involving cleaning of ceramics and printing and firing of thick film conductors. The final inspection document is a Teledyne quality assurance document describing the inspection procedure and the criteria for acceptable substrates. Three conductor layers on the front side, two conductor layers on the back side and the intermediate layers can be readily observed in the flowchart. It is noted that the standard process for this circuit involves two sequential firings of dielectric before the next conductor layer. This is done to make absolutely sure that there are no blowholes or pinholes in the dielectric that would cause electrical shorts with upper conductors. The above processes will not be discussed in detail here because they are standard thick film multilayer substrate fabrication processes followed throughout the industry.

1.2.1.1.2 Assembly Processes - The assembly process flowchart is shown in Appendix A. This flowchart again shows operations in the lefthand column and process numbers in the second column. The details of the processes are described below.

Product identification and regulator resistor attach using solder are standard processes and will not be discussed further.

Component attach is the process of attaching the red and green light emitting diodes on the substrate in a matrix. This involves epoxy screening of the substrate using a standard screening process and subsequent attach of devices using a computer-controlled automatic die attach machine called Video Auto Die Bonder made by FOTON. This bonder was adequately described in the original proposal. A TM process procedure has been finished on the FOTON die bonder and included in Appendix B. Lead bonding after component attach will be done on the Hughes 2460 automatic thermosonic bonder with

pattern recognition capabilities. This bonder with pattern recognition is expected to bond at an average rate of 1.5 to 2 wires per second, including the time of setup, etc. This will enable TM to bond one circuit in less than an hour. The details of this process will become clear in the description of problem areas.

Heat soak, temperature cycling and regulator resistor attach are standard TM processes used on a large number of other projects. Since they are not program peculiar, detailed descriptions of those processes will not be included here. Heat soak test condition H involves storage at 125°C for 24 hours and thermal cycling. Test condition F has limits of +85°C and -10°C for 10 cycles. (Note: Test condition letters are Teledyne identifiers, not Military Standard letters.) Regulator resistor attach is a standard soldering process.

The lens attach encapsulation process includes installing the collimator, potting the populated and bonded substrate along with the collimator with optoelectronic epoxy compound, and subsequent grinding and polishing of the whole assembly.

1.2.1.2 Problem Areas and Limitations

1.2.1.2.1 Component Attach - As described in the original proposal, the FOTON machine consists of two asynchronously operated X-Y tables, one for a dice wafer on an expanded mylar hoop and one for the substrate; a die poker below the wafer on mylar to release it from the wafer; a specially designed vacuum pick up; a pattern recognition mechanism to align and pick up the die; and an optical sensor to verify the presence of a die in the collet. With all the systems working perfectly, the machine can pick up and place 6,400 dice in one hour, thereby easily exceeding the rate of 1 substrate per hour. Several problem areas were associated with the whole operation causing reduction in this rate as described below:

1. The red and green dice within a given pixel have to be within 3 mils or less of each other. This requirement is

imposed because of the presence of the collimator. The original construction of the die pickup tool shown in Figure 10 is such that after placing all the dice of one color, placement of dice with the other color at such close proximity proved to be impossible because the wall of the die collet interfered with the previous die and displaced it out of its optimum position.

2. The first die placed also created a mound of epoxy around its periphery due to placement pressure. This again was disturbed during second die placement because placement of the second die tended to disturb that epoxy mound and since these dice are so light, excessive epoxy makes them float on top of the epoxy.
3. The optical die sensor did not work very well because the vacuum hole in the die collet was too small (see Figure 10) to allow enough light to pass through the collet and strike the optical detector when no die was present in the collet. When the machine fails to detect the absence of a die and keeps working, the collet gets submerged in the die attach epoxy. This obviously requires collet cleaning before the attach process can be resumed.
4. One problem that held up delivery of the Foton die attach machine purchased under the MM&T contract was the circumstances surrounding the NEC LED's with respect to their position on the membrane, the properties of the membrane material, and the mechanical dimensions of the supporting hoop. The machine was finally delivered without resolution of these problems and activity has proceeded at Teledyne to arrive at final solutions.

The LEDs were supplied on a 3 inch diameter hoop while the Foton machine is designed for a 5 inch hoop. An adapter was made to accommodate this difference but the next

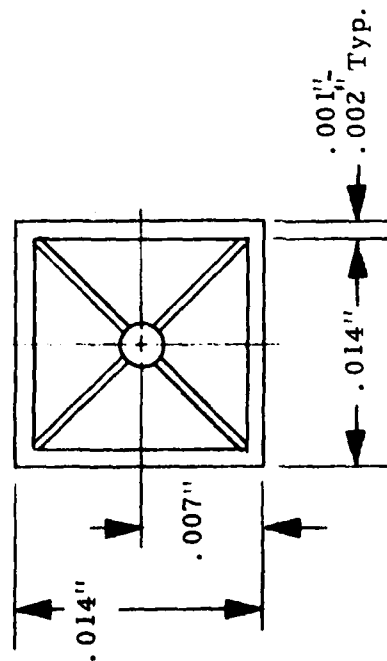
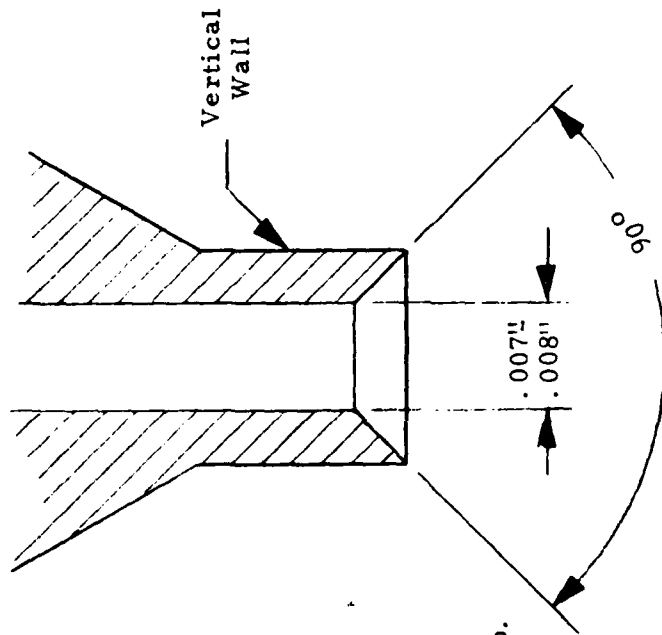
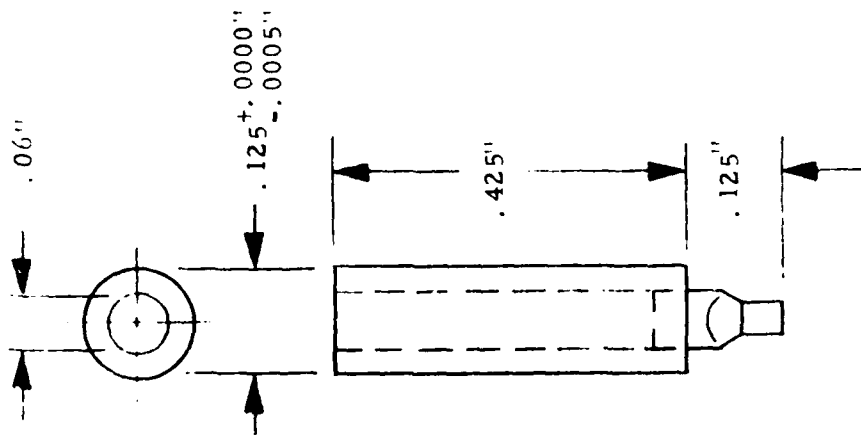


FIGURE 10. Die Pick-up Collet

problem was that the plunger mechanism that pushes the dice up off the membrane interfered with the hoop before the perimeter dice could be removed. This does not affect basic machine operation but leaves a large number of dice around the outer edge of the LED wafer that are unavailable for pick and place. Thus it was an economic problem. The approach used at Teledyne to test the machine and build engineering models was to cut the membrane and its wafer from the 3 inch hoop and using Foton mounting equipment place it on a 5 inch hoop. The double membrane did not appear to affect machine performance.

The next problem encountered was that the wrong membrane material was used on the first shipments of LEDs. The symptom was slow recovery time from the distortion that occurred when the plunger pushed an LED up off the membrane. This distortion tilted the adjacent LED and persisted until it was in position for pick-up. This in turn changed light reflection and confused the image recognition system and also made pickup difficult. The solution was to use a program option in the Foton machine to pick up only every second LED which was outside the distorted area. The remaining LEDs were picked off later after distortion recovery. Later shipments from NEC used the proper material and the problem disappeared.

The most persistent problem was related to the fact that the 10 mil LEDs were spaced 10 mils apart on the membrane (on 20 mil centers) and the rows and columns were distorted and curved in some areas instead of being straight as shown in Figures 11 and 12. The very small size of the LED dice requires high optical magnification in the machine to obtain the required positioning accuracy from the image recognition system. But this also magnifies the curvature. The lock-on range of the imaging system with these optics is about



FIGURE 11. Expanded Membrane
Unacceptable dice have been physically removed.

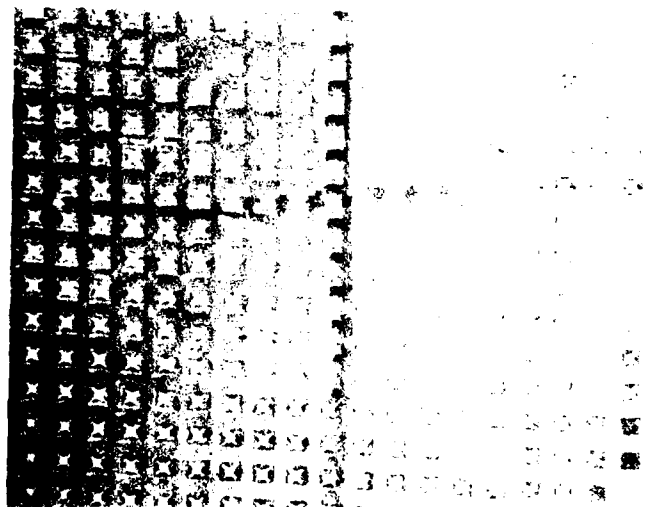


FIGURE 12. Expanded Membrane
Note excessive die to die distance and nonlinearity

± 3 mils. Therefore, a kerf deviation from linearity of only about 8 degrees causes the machine to lose lock-on capability and requires manual intervention to recapture it. This has a serious impact on machine operating rate that would not be acceptable for a production program. If the dice were on 12 mil centers (2 mil kerf) the critical angle would increase from 8 to 14 degrees and thus it would take very large nonlinearities to cause loss of lock-on, and this problem would be eliminated.

However, the ideal solution is to have the LEDs on 12 mil centers with perfectly straight line kerfs in both rows and columns. This should not be a difficult requirement if the wafer is sawed on the membrane and not stretched. Such LED wafers were observed in a demonstration of the Teledyne TAC LED attach machine which was placing 52,500 LEDs on 14 mil centers without image recognition.

The maximum Foton machine operating rate occurs when the LEDs are on fixed linear centers and no position corrections are required for individual dice. Some portions of the NEC wafers exhibited this characteristic and machine rates of 6400 dice per hour were observed. If small corrections are occasionally required by the imaging system, the machine rate is slowed slightly. If large corrections are required for all LEDs due to kerf curvature, the machine rate is slowed considerably. For nonlinear portions of the wafer that were within lock-on capability, the machine rate would be as low as 3000 dice per hour. If image lock-on is lost, the machine slow down is serious.

One other problem with the die wafers was related to the visual inspection performed by NEC. During this inspection the unacceptable dice were physically removed. This also accumulated the positioning error when the FOTON

optical recognition had to jump through two die locations to get to an acceptable die. It should be noted in considering the above discussion that the actual die positioning capabilities of the FOTON machine are better than ± 0.2 mils.

1.2.1.2.2 Lead Bonding - On the Litton Display program, lead bonding was done on the Hughes 1460 automatic thermosonic bonder, which has a maximum speed of one wire per second. Since the bonder used at that time did not have optical recognition capabilities or a computer program specifically made to handle a uniform field of 10 mil X 10 mil diodes, the bonders could not be used very efficiently. Programming was performed on an actual display unit with imperfections in die placement caused by problems described in the previous section. Additionally, the 1460 bonder with three RAM cards could handle about 600 wires in its program. It was therefore necessary to divide the field of diodes into 8 equal parts of 512 wires each and bond each field individually. In conclusion, with the available automatic equipment setup, bonding was performed at a rate of about 600 wires per hour. For the purposes of this contract the rate will have to increase to about 4,000 wires per hour.

1.2.1.2.3 Lens Attach and Encapsulation - This process is extremely critical to ensure acceptance at final electrical and optical tests and consists of collimator placement, potting and curing of optoelectronic encapsulant, plus grinding and polishing to prepare the final display,

Several important syndromes were discovered during this operation when Litton display modules were being built. Some of the problems, such as the fact that the optoelectronic encapsulant could not withstand over 100°C temperatures, have already been discussed. Handling damage to wraparounds was also addressed earlier. Some other areas of concern during the previous processing were as follows:

1. The tooling itself caused some amount of handling damage, especially on the corner pads.

2. The corner dice or pairs of dice tended to lift up during grinding due to epoxy separation from the substrates.
3. The grinding process became extremely critical. Tolerance on the order of .001 inch over the entire length of the display had to be held in order to get the whole display under the 2.88 inch X 1.44 inch maximum dimension. The existing surface grinder/angle block combination was not good enough to meet such tight tolerances.
4. The process, and especially the tooling, caused excessive amounts of epoxy to go down the sides of the ceramic to the backside. This made it difficult to remove the display unit from the tooling and, secondly, in some cases the epoxy got on the solder pads and required abrading before the other hybrids in the module could be soldered to the display.

1.2.1.2.4 Process Documents - Three different processes were discussed in the above section. The process documents prepared for the Litton display program are included herewith as Appendix B. It will be clear from the next section that modifications to these processes are being prepared presently based on the changes that will improve the throughput and efficiency of the overall build cycle. The whole area of new tooling is separated from this section and addressed later in this presentation.

1.2.1.3 Problem Resolutions

1.2.1.3.1 Component Attach - In order to solve the problem of die placements in close proximity, and to improve the total light output to the sensor, the die collet was modified as shown in Figure 13. Since one side of the collet is removed, there is no conflict during placement of the other die color provided the die collet is turned in such a way that the cut portion of the collet ends up toward the die that is already present. It can also be seen that the collet shank design has been

changed to allow more light to pass through the collet to the sensor. The first of the above modifications was done on the existing tools to solve the problem on Litton display units, thereby proving its feasibility.

The second problem related to epoxy screen printing was solved by controlling the epoxy print thickness to about 1.5 mils. With this thickness there was enough epoxy to form a satisfactory bond between the die and the substrate and at the same time it did not cause formation of a mound which would eventually float the next die to an unacceptable position.

The problem with the wafers is being pursued vigorously at the present time. Personnel from TM recently visited Japan in connection with this and other problems. Mr. Ralph Redemske of Teledyne specifically visited NEC and SANYO (both are LED manufacturers) to explain the problem to them and arrive at reasonable solutions. Detailed reports of his trip are included herewith as Appendix C to give a general idea of progress made so far and the action items to be fulfilled to achieve designed die bonding capacity on the FOTON machine.

- 1.2.1.3.2 Lead Bonding - TM took delivery on a new Hughes 2460 automatic thermosonic wire bonder in the early part of February 1981. This machine has a theoretical throughput rate of four wires per second. It also has a large variety of functions that would make it especially suitable for the display program. The X-Y table on the machine moves at 0.1 mil increments, thereby making it very accurate.

TM has given a contract to Hughes Aircraft Company, Carlsbad, California, to develop an automatic step and repeat program for the Hughes 2460 machine. This program will have optical recognition software included in it. The image size on the standard optical recognition unit is about 80 mils X 80 mils. The system looks at an area of about 40 mil² at any given time. Obviously these areas are too large for distinguishing 10 mil x 10 mil diodes. A 2X objective is therefore being added to the optical recognition TV camera to reduce the size of the field of view. Additional changes will also be made to make the system

zero in on the center of the die. The step and repeat program will basically ask for two substrate references and two each die references for red and green diodes. It will also require the operator to manually place the first red and green diode bonds. From that point on the machine will calculate the bond profile and step and repeat exactly at 45 mil intervals to make the rest of the bonds. If the FOTON machine works well and, as a corollary, the die wafers and epoxy-screened substrates are satisfactory, the die-to-die placement error throughout the field of diodes will be ± 0.7 mils or less. With that kind of error, optical recognition will not even be necessary for the lead bonder. If the error is greater, the Hughes 2460 software will have a provision to use optical recognition whereby the machine will actually search for the die pad center and make the bond before moving on to the next bond. The optical recognition will slow the machine down but it should still make about 6,000 bonds per hour, which will easily meet the production rates scheduled for this contract.

- 1.2.1.3.3 Lens Attach and Encapsulation - Modifications are being designed to prevent tooling from causing handling damage. Additionally, notched ceramic with the presence of wraparounds inside the depressions will eliminate the handling damage.

Notched ceramic along with modified tooling will help the corner lifting problem because with notches the encapsulation epoxy will run down the notches and form a better bond at the corners between the epoxy and ceramic. With notched ceramic the grinding process will not be so critical since the grinding wheel will only contact the outside portions of the ceramic and not the wraparounds.

Two new pieces of equipment which will be very useful on the MM&T program are being considered for another contract. The first is a surface grinder called HARIG Super 618W Automatic II surface grinder sold by Machinery Sales Co. of Los Angeles, California, and the second is a polisher called Model 6 BK Ring Precision Polishmaster, sold by R. Howard Strasbaugh Inc. of Long Beach, California. These two items will enhance production rates and yield a higher quality product

because the operations of polishing and grinding will be basically mechanized. It is expected that these two pieces of equipment will readily meet the throughput requirements of 35 displays per day.

1.2.1.4 Conclusions

The discussion of process problems and resolutions should indicate the high degree of confidence attained by TM on this program. The estimated rate of 35 displays per day will be readily demonstrated on an extrapolation basis as indicated in the original program proposal. Optimum rate of the FOTON machine is expected to be about 5,000 dice per hour and that of the 2460 wire bonder will be 6,000 to 7,200 wires per hour, depending on the necessity for optical recognition. Even allowing for loading, unloading, and up to 5% down time, the rate of production should be high enough to produce 7 to 8 displays per day. With well established practices, the grinder and polisher will achieve much higher rates of production and may even meet the 35 per day requirement. It is clear that changes will be required on present processes as various modifications discussed in the previous section come to fruition and an efficient line operation is established to manufacture the LED displays required for this contract.

1.2.2 Test Equipment

1.2.2.1 LED Panel Exerciser

A. Function

The Teledyne display exerciser provides a convenient means of exercising the Teledyne LED display panels. With the exerciser alone, the LED panels (Teledyne Part Numbers 2274705 and 2274715) can display ASCII characters and graphic symbols. When supported by an off-line computer via the built-in RS-232C input, the exerciser can display the same ASCII characters and graphic symbols, and in addition can selectively light any or all of the pixels in any of the three LED colors (red, green, amber).

B. Problems and Solutions

1. The primary problem was that the MM&T specification implied that each LED should be driven at 100 mA, and on the other hand required that all LEDs in the panel could be lit at the same time. Meeting this requirement with the column sink drivers normally used with these panels was impossible because the drivers were rated for 1.5 amps max, while driving all 64 LEDs in a column would require a sink capability of 6.4 amps. In order to resolve the situation, the LED drive current was limited to approximately 25 mA each, making the total column sink current approximately 1.6 amps.
2. Another problem was the rate at which the LEDs were to be driven in order to produce a flicker-free display. Initial information implied that an update rate of approximately 500 times per second would be required. With the microprocessor which was used to control the exerciser (6502), a rate of 500 per second was not achievable. Teledyne Microelectronics finally settled for an update rate of approximately 170 times per second, which produced a reasonably flicker-free display.

C. Conclusions

The LED panel exerciser successfully met all the requirements of the MM&T specification.

D. Applicable Drawings

SK1034375	Assembly, LED Panel Exerciser
SK1034374	Assembly, Test Fixture
SK1034373	Operating Instructions, LED Panel Exerciser (See Appendix D)
1034372	ROM Common Operating System

SK1034371	ROM Character Generation
SK1034370	Assembly, Exerciser Display Driver
SK1034369	Assembly Modification of LAMAR Instruments PC Board
SK1034368	Assembly, Keyboard

1.2.2.2 LED Panel Production Test System

- A. The primary function of the production test system is to verify that the LED panels which come off the production line operate correctly, i.e., to perform an acceptance test. In addition, the system will be used for an in-process test to isolate malfunctions while they can still be repaired. On the preliminary flowchart (traveler), these tests are referred to, respectively, as INITIAL ELECTRICAL TEST and FINAL ELECTRICAL TEST. Another use for this system will be to verify that the peak emission wavelength of LED dice is correct.
- B. Requirements of the MM&T Specification for Acceptance Test
 1. The basic requirement is to perform the acceptance test (Group A) of a three color LED display module according to the requirements of its specification: MMT-799938, dated 22 March 1979.
 2. The module consists of a 32 row by 64 column matrix of red and green LED pairs. Each pair can be lit to display red, green or amber (red and green together). Each pair has a built-in reflector and the whole assembly is encapsulated.
 3. In order to perform any testing, an interface must be supplied which can drive each LED at the specified current: 100 mA (Para. 3.2.6.1, 3.2.6.2).
 4. Each LED pair must be measured for luminance (brightness) of the red and green colors with no filter or other obstruction

between the LEDs and the measuring instrument: red - 1000 foot-lamberts at 3% duty cycle (Para 3.2.6.1), green- 1150 foot-lamberts at 3% duty cycle (Para 3.2.6.21).

5. Each LED pair must be measured for peak emission wavelength (color) of the red and green colors: red - 625 to 675 nanometers (Para. 3.2.6.1), green - 545 to 575 nanometers (Para 3.2.6.2).
6. With a piece of treated paper (or its equivalent) placed on the surface of the LED module, each LED pair must be measured for contrast ratio for each of the three colors: contrast ratio - 3:1 (Para 4.9 b).
7. With the treated paper in place, each LED pair must be measured for the spot size projected onto the exposed surface of the paper. The colors to be measured are not defined, nor is the shape of the spot. However, the spot must have dimensions as follows: 0.035 X 0.035 inch (Para. 4.9 d).

C. Problems and Solutions

The single biggest problem is that the time required to make one brightness measurement with commercially available photometers is approximately 50 milliseconds. As a consequence, the time required to perform the test of B.4 (above) is approximately 3 minutes and 20 seconds. The test of B.5 would require approximately 33 minutes. The test of B.6 would require approximately 5 minutes. The test of B.7 would require approximately 33 minutes. The time then to perform all of the required tests would be approximately 74 minutes. One system, then, could only test eight parts per shift for acceptance. The specification, however, also requires that Teledyne demonstrate a capability to produce 35 LED panels per shift. This requirement would mean that a minimum of 5 systems would have to be built.

One might ask at the point, "How do the tests of Section B prove that the LED panel was built correctly?" If the B.4 test is passed, then the panel must have been assembled correctly and the brightness of each LED is acceptable. If test B.5 passes, then the panel was assembled correctly and the color of each LED is acceptable. If test B.6 passes, then the panel was assembled correctly and the design of the panel is correct. If test B.7 passes, then the panel was assembled correctly and the design is correct. Tests B.6 & 7 only serve to prove that the panel design is correct, so why do them to re-verify that the panel was assembled properly. Test B.5 only shows that each LED has the right color, but this can be shown to be correct by sample testing the peak emission wavelength of LED dice from every wafer that is used.

The net result of all this is that the only tests which are really needed are B.4 and a sample test for color of dice from each LED wafer. By only testing for brightness of each LED, well over 100 LED panels can be tested in an 8-hour shift. This easily allows initial testing of 35 panels, final testing of 35 panels, retesting of more than 30 panels, and time for sample testing LED dice for color.

C. Conclusions

The production test system will be designed only to test brightness of each LED and to do a sample test for color of LED dice.

A block diagram of the system is shown in Figure 14.

1.2.3 Tooling for Production

As the present effort is to design production tooling, it is necessary to examine the operations, techniques and sequences of operations used to produce the several LED display assemblies produced to date. Completed displays indicate design feasibility and present a certain logical sequence of fabrication operations to be organized into a manufacturing sequence and then supported by necessary tooling to be designed to

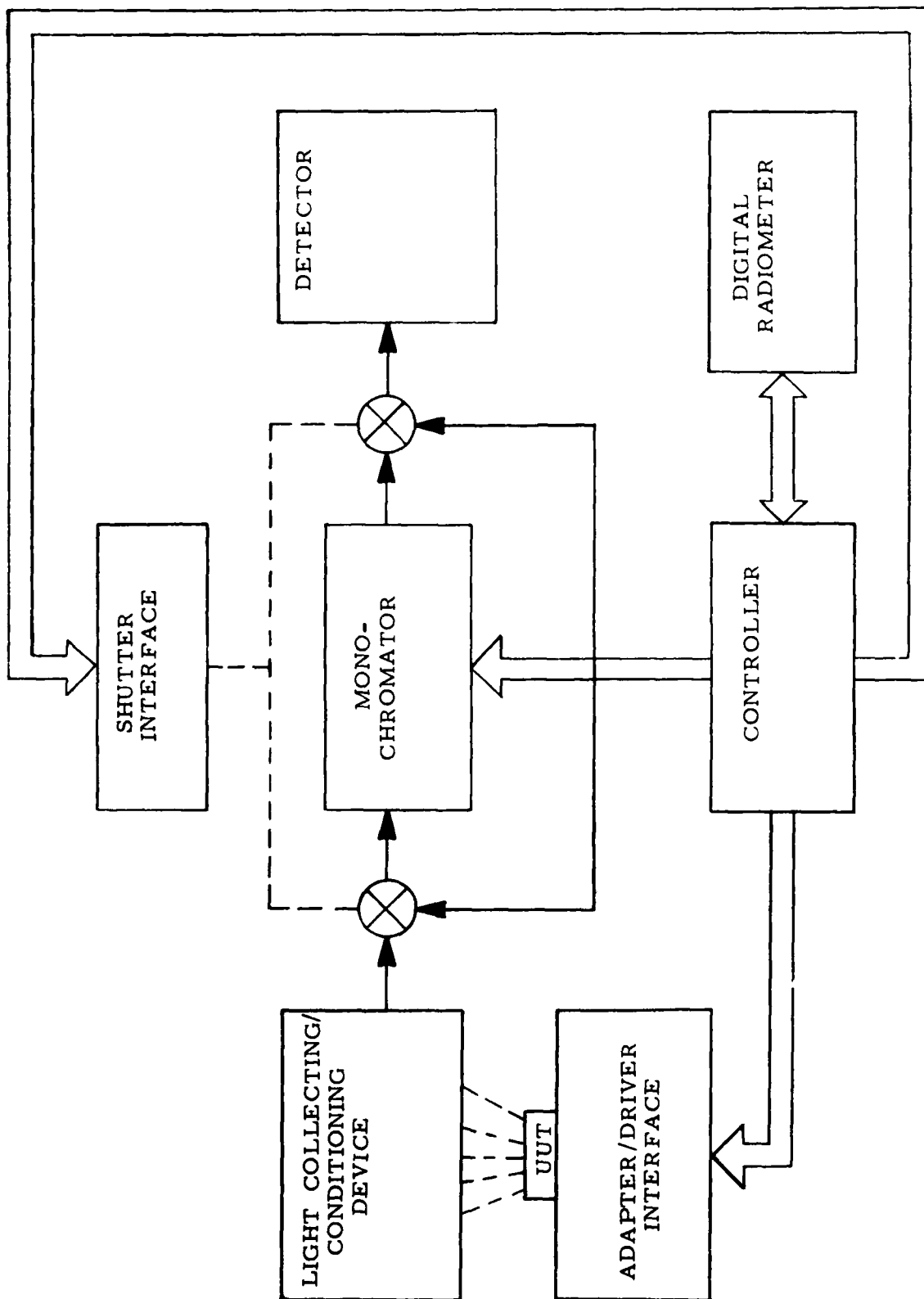


FIGURE 14. OPTICAL TEST SYSTEM BLOCK DIAGRAM

the concepts as defined by a precise manufacturing procedure. Existing units were produced in the laboratory by experimental or developmental personnel. Their techniques are being examined for inclusions, modification or elimination in the production phase. All changes are based on the requirement of production rate. Another consideration incorporated in developing a production capability is the quality assurance and reliability level that can be expected from each operation or technique, as well as the tooling to support it.

In all, eight specific areas will be carefully addressed in order to develop a production manufacturing capability for the target production rate. These are:

1. Product Design for Production Manufacturing
2. Alternatives (for Cost, Quality Assurance, or Production Rate)
- *3. Manufacturing Sequences and Operations
- *4. Tooling Concepts
5. Tool Drawings or Designs
- *6. Machinery Support
7. Quality Assurance and Reliability (Not inspection!)
8. Off-Site Tooling Requirements

1.2.3.1 Product Design for Production Manufacturing

Designs of detail components of the LED display are being reexamined to ensure that all details and/or subassemblies are dimensionally coordinated to permit full dependency on the production tooling to precisely locate and orient parts for assembly without visual observation for adjustment or alignment. Slight revisions of detail designs bring common dimensioning practice and coordination. Detail parts will index from the same end to allow precise registration in assembly tooling. Conflicting tolerance accumulations are eliminated. Micro-spacing of circuitry and diodes make this concept mandatory.

* Interdependent

1.2.3.2 Alternative Considerations

Per present design the collimator has been produced by the compression molding process of a filled phenolic. After molding, a reflective coating is applied. It is a workable concept, but does require a machining operation after molding to reduce overall thickness to the dimension prescribed in the design. The excess molding thickness is necessary in order to mold a piece of this particular geometry. After assembly to the display substrate, the wide borders on both sides and both ends are trimmed off. These borders were also for reinforcement during the molding process.

In the interest of cost effectiveness and removing superfluous operations, several alternative methods for producing a collimator are being investigated. Methods under examination should allow the fabrication of a part without excessive trim requirements, while increasing the quality assurance and reliability level. It is inappropriate to define or describe any method under study at this time as the search is not confined to any group that has been examined to date.

1.2.3.3 Manufacturing Operations and Sequences

Displays produced so far have been fabricated by laboratory technicians on a prototype basis. Some tooling or aids were used to fabricate these assemblies. Careful examination of all operations is being made in order to develop a production manufacturing program. Some operations may be altered or eliminated when the production tooling is developed and the production program is begun.

1.2.3.4 Tooling Concepts

Production tooling concepts will be based on three fundamental requirements, as follows:

1. Production rate required.
2. Uniform and positive location of piece in assembly or machining fixture.
3. Development of fixtures for single piece or multiple quantity, based on advantage or possibility at each operation. Some examples:

A. A "carrier" fixture will hold but one piece, but travel through several operations

- (1) Attach diodes
- (2) Bond wires
- (3) Electrical test

Several of these fixtures will be required to support the production rate.

B. A gang fixture holding eight pieces is being designed for grinding the top surface of the collimator after assembly and potting to the display substrate. Another gang fixture for six or eight assemblies is contemplated for edge trimming of collimator borders.

C. Fixtures for single pieces for use at a single operation. Multiple quantity will be required for the production rate support. Lapping fixtures and potting fixture are in this group.

1.2.3.5 Tool Design Drawings

Drawings for production tooling are in progress at this time. The concepts are based on the specific operation to be accomplished, either carried over from the prototype fabrication or improved to match the manufacturing program to be initiated. Some concepts

are based on the type of machinery to be obtained for the production program. A tentative list for production tooling follows, although all have not yet been designed:

1. Carrier fixture (holds single substrate) - several fixtures for installation of diodes, wire bonding, electrical testing.
2. Vacuum chuck grinding fixture (holds eight pieces) for grinding the top surface of the potted and cured collimator after assembly (one fixture only).
3. Potting fixture (holds single assembly) - several fixtures for aligning and securing the collimator and display for pouring and curing epoxy.
4. Lapping fixture (holds a single assembly) - several fixtures for lapping top surface of the display assembly after surface grinding of collimator top surface.
5. Trim fixture (holds six to eight pieces) for trimming end borders from collimator after potting.

1.2.3.6 Machinery Support

Certain machines will be required to match the tooling concept and support the intended production rate. Only three examples are shown here, but more may be added as the program develops.

1. Surface grinder (6 in. X 18 in. capacity) - used with vacuum chuck.
2. Lapping machine (no specifics defined at this time) to lap and polish the top surface of the collimator after surface grinding.
3. Trim saw (undefined at present) to be used for straddle sawing; two saw blades on single arbor for trimming collimator end borders after potting; table travel of 9 to 10 inches minimum appears desirable.

1.2.3.7 Quality Assurance and Reliability

Precision tooling, coordinated dimensioning of detail part drawings and positive registering of parts in tooling for fabrication and assembly will assure uniformity of pieces and assemblies. Production rate will be greater while any rejection rate will become very low. This should prove cost effective for each unit assembly.

1.2.3.8 Off-Site Tooling Requirements

1. Collimator funding will be required for molds used in the off-site molding of phenolic collimators.
2. A grinding fixture must also be funded for use by the phenolic molder. Excess material is removed before delivery to Teledyne.

1.3 FLOWCHART OF MANUFACTURING PROCESSES

No manufacturing has yet been completed under this contract. Therefore, the information requested cannot be provided in this report. However, the estimates remain the same as stated in the proposal.

1.4 EQUIPMENT AND TOOLING

Approximately 800 manhours were required to design the test exerciser. No cost data is available yet for the acceptance test system; the estimate remains the same as that stated in the proposal. Replacement costs for tools purchased under this contract are as follows:

- A. Automatic die attach machine, spare parts, and associated accessories total \$76,030.00.
- B. Automatic lead bond machine and associated peripheral equipment total \$66,575.00.

Capacity cannot be determined yet, as production has not begun,

but estimates are given in Paragraph 1.1 The U. S. Government is the owner of equipment and tooling designed or purchased under the contract.

1.5 DATA AND ANALYSIS

No units have as yet been fabricated; therefore no data is available.

1.6 SPECIFICATION

Although no units have yet been built, analysis of the device requirements and information obtained in the design of test equipment have led to the following recommendations for specification changes.
(All paragraph numbers referenced in this section refer to ERADCOM Technical Requirements No. MMT - 799938.)

1.6.1 Paragraph 3.2.2

This should be altered to give the height and width dimensions as 1.436 inches \pm 0.003 inches and 2.876 inches \pm 0.003 inches to reflect current design.

1.6.2 Paragraph 3.2.4

This should be deleted to reflect current design.

1.6.3 Paragraph 3.2.5

This should be deleted, since no flexible printed circuits are used in the current configuration.

1.6.4 Paragraphs 3.2.6.1 and 3.2.6.2

These should have the wording "minimum light output" changed to "minimum average light output".

1.6.5 Paragraphs 3.4.1.1.1 and 4.10.1

These require operation without degradation in air at a temperature as low as 0° C. This requirement cannot be met in general since if the dew point of the ambient air is higher than 0° C, frost will form on the display panel and reduce light intensity output. It is suggested that the words "without degradation" be deleted.

1.6.6 Paragraph 4.9a

This specifies a transmissibility of 40% \pm 2%. Available photometers for use in an automatic test system have absolute accuracies of only \pm 5%. Either the \pm 2% tolerance must be broadened to \pm 7%, or the requirement should be interpreted as \pm 2% relative to the photometer reading.

1.6.7 Paragraph 4.9d

This should have the wording "projected diameter of at least 0.035 inches by 0.035 inches (0.089 cm by 0.089 cm)" changed to "projected diameter of at least 0.035 inches (0.089 cm)".

1.6.8 Appendix A

This drawing should be replaced with the drawing shown in Figure 1 of this report to reflect the current design.

1.7 REQUIREMENT FOR PILOT LINE

During 1981 Teledyne Microelectronics will expand, refurbish, and rearrange its facilities extensively. Included will be the establishment of a pilot line for the MM&T program. A 580 square foot room has been dedicated. An automatic die attach machine and an automatic bonding machine, both of which have been purchased and received

will be moved into the room along with the tables and conventional tools needed to set up the line. The plan calls for the room to be in operation in September, 1981; at that time three technicians will be assigned to man the line, one for each of the automatic machines and one for other operations.

1.8 COST FOR PILOT RUN

The pilot run has not been made yet; therefore, this information cannot be provided in this report, but estimates remain in conformance with those given in the proposal.

1.9 PROGRAM REVIEW

This item has been submitted under separate cover in compliance with Contract Line Item 0004AB, "Monthly Fund Expenditure Report".

2. CONCLUSIONS

For the first six months of this program, the major accomplishments were:

The delivery to Teledyne, installation, and operation of an automatic LED attach machine.

The delivery to Teledyne, installation, and operation of an automatic wire bonding machine.

The design, fabrication, and delivery to the contracting agency of an LED Panel Exerciser.

The submission and approval of a Quality Assurance Plan for the program.

Detail producibility improvements in the design of the LED panel.

Conceptual design of the LED Panel Acceptance Test System.

Definition of required mechanical tools and equipment.

The program is on schedule, and it is anticipated that it will remain on schedule. Based upon the results obtained in the first six months, there is a high degree of confidence that all objectives of the program will be met.

Technical problems exist in regard to the quality of the LEDs procured on stretched membranes and in regard to sources for an acceptable collimator, but efforts to resolve these problems are under way and will be successful during the next reporting period.

Estimated percentages of overall progress on the major elements of the project are as follows:

<u>SLIN</u>	<u>TITLE</u>	<u>PERCENTAGE PROGRESS</u>
0001	Manufacturing Methods and Technology (MM&T) Project to establish automatic production techniques for Three Color Light Emitting Diode Display Modules meeting ERADCOM Technical Requirements MMT-799938 and in accordance with ERADCOM Industrial Preparedness Procurement Requirements (ERADCIPPR) Number 15.	25%
0002	Test Exerciser System	100%

<u>SLIN</u>	<u>TITLE</u>	<u>PERCENTAGE PROGRESS</u>
0003	Production Capability Demonstration	0%
0004	Technical Data for Functional Category A, Administrative/Management IAW CDRL, DD Form 1423.	35%
0005	Technical Data for Functional Category E, Engineering and Configuration Docu- mentation IAW CDRL, DD Form 1423.	100%
0006	Technical Data for Functional Category P, Procurement/Production IAW CDRL, DD Form 1423.	0%
0007	Technical Data for Functional Category R, Related Design Requirement IAW CDRL, DD Form 1423.	40%
0008	Technical Data for Functional Category S, System/Subsystem Analysis IAW CDRL, DD Form 1423.	25%
0009	Technical Data for Functional Category T, Test IAW CDRL, DD Form 1423.	33%

3. PROGRAM FOR NEXT INTERVAL

In conformance with the previously submitted PERT chart for this contract, the following program will be followed in the next six months:

1. All tooling design will be completed and the tooling will be fabricated.
2. All parts and materials for both the confirmatory samples and the pilot run units will be procured.
3. The test plan for the confirmatory samples will be prepared and submitted for approval.
4. The confirmatory samples will be fabricated.

4. PUBLICATIONS AND REPORTS

There have been no publications by Teledyne Microelectronics under this contract, or concerning this contract, except for reports on trips that Mr. R. F. Redemske made to Sanyo and NEC in Japan regarding the procurement of LEDs. These reports are included in the appendixes.

5. IDENTIFICATION OF KEY PERSONNEL

The table below lists key personnel, their functions, and the hours each has worked on the program during the first six months. Additional hours have been expended by other personnel.

NAME	FUNCTION	HRS. WORKED
G. Lewis	Program Manager	352
L. Bechtel	Project Engineer	56
F. Castelo	Project Engineer	16

NAME	FUNCTION	HRS. WORKED
W. Combs	Design Engineer	164
D. Nelson	Test Systems Manager	108
K. Kleider	Test Engineer	582
J. Maize	Test Engineer	140
N. Patel	Test Engineer	101
R. DeBar	Tooling Engineer	39

APPENDIX A

ASSEMBLY FLOW CHARTS

THICK FILM SUBSTRATE MULTILAYER TRAVELER

PROGRAM
LITTON TDS

7C
RX 1984

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PART NO. 2274708	REV	PART NAME LED DISPLAY .045	LOT NO.	QTY.
CHARGE NO.		CERAMIC NO.	FLOW CHART NO. 8561973	REV NC

OPERATIONS	DOCUMENT NUMBER	QTY.		OPR	INSP	DATE	INSP	PASTE, TR NO.	S#
		IN	OUT						
CLEAN CERAMICS	7104875								
P/F 1ST CONDUCTOR	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F 2ND CONDUCTOR	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F EDGE WRAP AROUND	7104876								
	7104877								
P/F BACK SIDE COND	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F BACK SIDE COND	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F DIELECTRIC	7104876								
	7104877								
P/F 3RD CONDUCTOR	7104876								
	7104877								
P/F EDGE WRAP AROUND	7104876								
	7104877								
MFG FINAL INSPECTION	200-001								

ASSEMBLY FLOW

LITTON DSD

TRAVELER

[illegible]

APPENDIX B

ASSEMBLY PROCESSES

[illegible]

1. SCOPE

- 1.1 This procedure describes the automatic die attach of LED's on matrix type displays.

2. APPLICABLE DOCUMENTS

- 2.1 Applicable FOTON Video Auto Die Bonder Manual.
2.2 Component attach, TM 7105554.
2.3 Applicable subassembly drawing and parts list.

3.0 EQUIPMENT AND SUPPLIES REQUIRED

- 3.1 FOTON video Auto Die Bonder.
3.2 Die collets, Gaiser Tool Company.
3.3 Die wafers uniformly stretched on 5" dia mylar sheets.
3.4 Mild steel shim stock, .003" thick.
3.5 Substrate holding fixture.
3.6 Microscope, 100X and 400X with micrometer stage.
3.7 Low power microscope.
3.8 Tweezers.

4. SAFETY PRECAUTIONS

- 4.1 None

5. PROCESS PREPARATION

NOTE:

- (1) The software in this machine is specifically programmed for Litton Display project. Any programming to change the step and repeat distances or incorporate any other changes shall be done by process engineering only.
(2) All keys in this process shall be indicated by capital letters in parentheses. See Figures 1 thru 3 for key locations.

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A	16170	7108191
SCALE	REV	SHEET
		2

5.1 Epoxy Screening of Substrates

- 5.1.1 Using Epoxy screen required by the appropriate subassembly drawing, epoxy screen the substrate per TM 7105554.
- 5.1.2 Carefully load the substrate into the substrate holding fixture making sure that the screened epoxy, especially around edges and corners, is not smeared. Note that the substrate orientation is important during loading operation.

5.2 Die Collett

NOTE: Die Collett loading shall be performed by Mfg. Services.

- 5.2.1 Examine the working area of the die collett under high power. There shall be no chips or cracks in the working area of die collett. Reject all colletts with such defects.
- 5.2.2 After choosing an acceptable collett, load it in the head per FOTON MANUAL SECTION 4A-6. Note that the die collett has to be adjusted with the open side towards the operator. Whenever the top diode out of a two diode pixel is attached first and when the diodes in a single pixel have to be very close to each other.

5.3 Turning on FOTON Machine (from STAND BY Operation)

- 5.3.1 Turn ON motor switch.
- 5.3.2 Turn up brightness control on the TV monitor to a reasonable level.
- 5.3.3 Plug in illuminator jack. Reverse the above sequence to turn the machine off.
- 5.3.4 Load a dummy substrate in its holding fixture into the rear X-Y stage of machine.

5.4 Head Location Adjustments

- 5.4.1 Ejecter Adjustment
- 5.4.1.1 Load a blank mylar die ring on the ring holder.
- 5.4.1.2 Press program (ENA) then press (PUR). Cross hairs will appear on TV screen.
- 5.4.1.3 Press (STOP) to turn off (PUR) LED, then press program (ENA) to turn it off. The cross hairs will remain on TV display.
- 5.4.1.4 Turn on service (ENA).
- 5.4.1.5 Push (ECT) to see the impression of the ejector into the mylar sheet.

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A	16170	7108191
SCALE	REV	SHEET
		3

- 5.4.1.6 Adjust the screws under ejector assembly to bring the ejector exactly under the center of the cross hairs.
- 5.4.1.7 Turn off service (ENA).
- 5.4.2 Die Collett Pick up Position Adjustments.
- 5.4.2.1 Turn on program (ENA).
- 5.4.2.2 Place a piece of 3 mil shim stock between the ejector stage and mylar sheet in the ring holder.
- 5.4.2.3 Push (HPP). The bonding head will be in pick up position.
- 5.4.2.4 Manually apply slight downward pressure to make an impression on the mylar sheet, then push (SET).
- 5.4.2.5 Observe the impression of die collett on mylar sheet. Try to judge the X and Y displacement necessary to align the cross hairs with respect to the impression on mylar sheet as shown in Fig. 5.
- 5.4.2.6 Push (HPP). The DATA display will come on. Using variance buttons and the display, bring the impression of the collett to the center of cross hairs. Note that a change of one count on the display is equal to 0.2 mils. Variance buttons with ◀ and ▶ symbols will move the head in X direction. Variance buttons with ▽ and ▲ symbols will move the display in Y direction.
- 5.4.2.7 Push (SET) and repeat 5.4.2.1 thru 5.4.2.6 after changing the mylar sheet location each time until the bond head position is set exactly with respect to the cross hairs. Turn off program (ENA).
- 5.4.3 Die Collett Substrate Bond Location Adjustments
- Adjust substrate bond locations by using (HBP) key instead of (HPP) key and using the rest of the process indicated in section 5.4.2.
- NOTE: To adjust substrate bond location, actual die attach is necessary to judge the corrections in die locations. Perform die attach per Section 6.
- 5.5 Programming of Die Wafer X-Y Steps.
- 5.5.1 Load a good wafer stretched on mylar on wafer ring holder and align it by hand so that wafer rows and columns are parallel to TV screen edges.

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		4

5.5.2 Use (BGN), (END) or (LNU) wafer slice adjustments to bring a large continuous uniform field of dice in the viewing field of TV>

NOTES: (1) DO NOT PUSH (JUMP) when the cross hairs are on the screen. The cross hairs will disappear.
(2) If (PUR) LED is on, do not make any adjustments after the collet impression and ejector are adjusted. Turn off (PUR) LED by going through Program (ENA), (PUR) sequence.

5.5.3 If (PUR) LED is off, push (ADJ) and use the variance buttons to center a die with respect to the cross hairs.

5.5.4 Push (STOP) and then (DVA) next to TV monitor.

Turn the D-Video Align Knob until the kerfs are well defined and as wide as possible without losing any of the die edge white surface reflection.

5.5.5 Push (DVT) under TV monitor and then turn the Digital Video Test knob until the kerfs are black and well defined and the entire die surface is white on a good die.

5.5.6 After above adjustments are satisfactory, push (VID) to get back to normal video. Note that it is important to make DVA and DVT adjustments as accurately as possible to make the program work well.

5.5.7 Make sure that the die is still aligned with respect to the cross hairs.. if not, use (ADJ) and variance keys, then push (STOP).

5.5.8 Push Program (ENA) and then (ALIGN). A four square pattern will come around the central die and the pattern will start moving around in 0.2 mil increments until the computer learns the respective light outputs from the die and kerfs. If this step does not work and an error message comes on the display, readjust video. [Push (STOP) to erase error code.]

5.5.9 Push (JUMP) for die to die distance adjustment. A small image will appear within the die surface and start moving diagonally to a die in the row above the central row and to the left.

5.5.10 The image will then move to the die on the left of the previous die and then return to the original die on the central row. If the image starts moving in any other direction, push (STOP) and readjust video.

5.5.11 Push program (ENA) to turn it off. The program is now ready to be run.

6.0 OPERATIONAL PROCEDURE

6.1 Final Adjustments for Die Locations on Substrate

6.1.1 Push (STOP) and keep it depressed while tapping service (ENA). Flashing LEDs will come on above (STOP).

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SCALE	REV	SHEET
		5

6.1.2 Push (IMD) and (STOP) simultaneously until the substrate stepper motors start running, then release. The machine will automatically go to 0.0 location of substrate. NOTE: See Fig. 4 for 0.0 of substrate for the Litton Display program. Remember that 0.0 of substrate for the FOTON machine is not the same as 0.0 for the applicable subassembly.

6.1.3 Push (JMP) and then variance keys to see if the die-to-die distance in the program is accurate. Otherwise repeat Section 5.4. Turn off (JMP).

6.1.4 Push () and () simultaneously and then push (RUN). Machine will go to the end of the die row, reverse and start die pick up and placement. Push (STOP) after 3 or 4 dice are placed.

6.1.5 Remove dummy substrate from the substrate X-Y table. Place under a microscope and check for accuracy of placement. Refer to the applicable subassembly drawing and check all dimensions such as distance from the edges of the ceramic, distance from die-to-die, etc.

6.1.6 If a slight error in placement is found, use the (HBP) key. Per Section 5, make necessary adjustments by changing the count on the display using the variance keys; and after pushing (SET) and program (ENA) to disable the program panel, perform 6.1.4 to attach some more diodes.

6.2 Final Die Attach

6.2.1 When the die placements are satisfactory, repeat 6.1.2 to bring the substrate X-Y table back to 0.0. Remove dummy substrate.

6.2.2 Load a good substrate on the substrate X-Y table.

6.2.3 Push (JMP) and variance keys to see if die-to-die distance is properly programmed.

6.2.4 Push () and () simultaneously then (RUN) to start die attach.

6.2.5 Whenever the machine begins to drift away from a field of diodes or when the die-to-die distance is not according to the program, push (STOP) and repeat Section 5.5 to program in the new die-to-die distance. It would also be necessary to use wafer slice keys to bring the wafer to a new uniform field of dice.

6.2.6 Continue 6.2.4 and 6.2.5 until all the dice of a given color are placed and the machine returns to table 0.0.

6.2.7 If dice of two different colors are to be placed as in the Litton Display program, use the (RGS) key to change from one die location to the neighboring die location of a different color within the same pixel. For the Display program, (RGS) LED on will place red diodes and (RGS) LED off will place green diodes. (The green diodes are attached first).

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6.2.8 Continue through this section until all the diodes of the other color are placed.

6.3 Placing Individual Diodes

NOTE: This section shall be used whenever single diodes have to be placed into specific locations in the display board.

6.3.1 Push Program (ENA) and use (RGS) to set the machine for the appropriate color diode.

6.3.2 Note the exact coordinates of the diode to be replaced.

6.3.3 Push service (ENA) and then push (IDX).

6.3.4 Push the variance buttons and with the help of the display, move the substrate table to the exact X-Y coordinates. Note that () and () move the table in X direction and () and () move it in Y direction. The variance keys will move the count up only. If by mistake the count is moved beyond the die placement location, the table has to be brought back to 0.0 and the process restarted.

6.3.5 When the correct X-Y coordinates are reached, push service (ENA) 3 times to turn off all service LEDs.

6.3.6 Push (RUN) and immediately push (STOP). A single die will be placed at the appropriate spot.

6.3.7 Repeat 6.3.1 through 6.3.6 for additional dice to be placed.

6.4 Epoxy Cure

6.4.1 Inspect the entire display substrate carefully. If any dice are missing, use Section 6.3 to place new dice at the correct locations. If dice are displaced to wrong locations, correct their locations as required. Note that for auto bonding to succeed, die bonding pad locations have to be exact within .001".

6.4.2 If die placements are satisfactory, place the substrate, along with the substrate holder in a curing oven and cure per the appropriate schedule called out in TM 7105554.

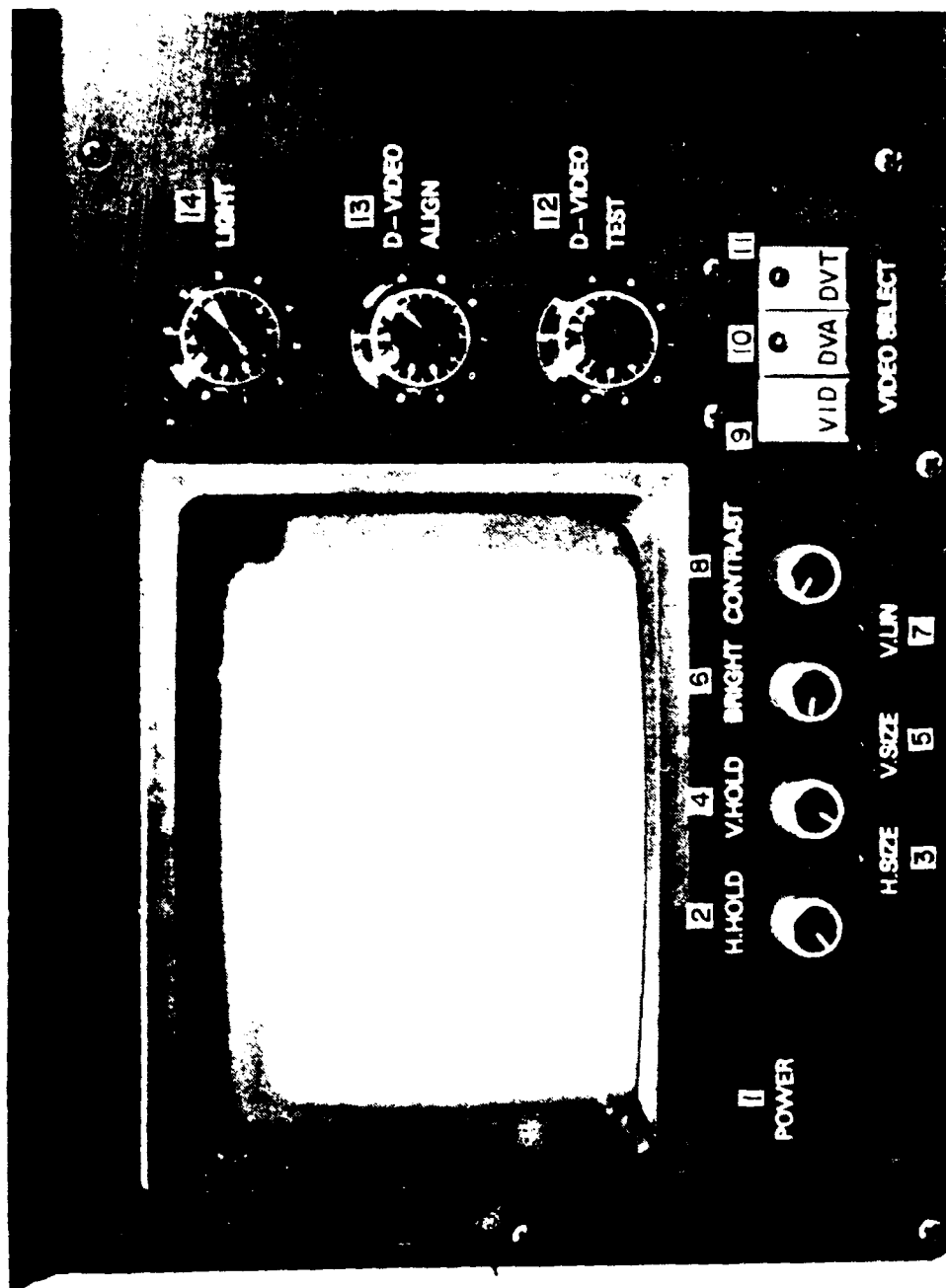
7. SPECIAL PROVISIONS

7.1 The (TST) LED comes on for each diode placement.

7.2 The missing die detector based on light emission through the die collet is not being used at this time. The detector is disabled by pushing Program (ENA) and then (ECC) to turn that LED on.

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WAFER MONITOR



2-3

7108191

8

FIGURE 1

TERMINAL KEY BOARD

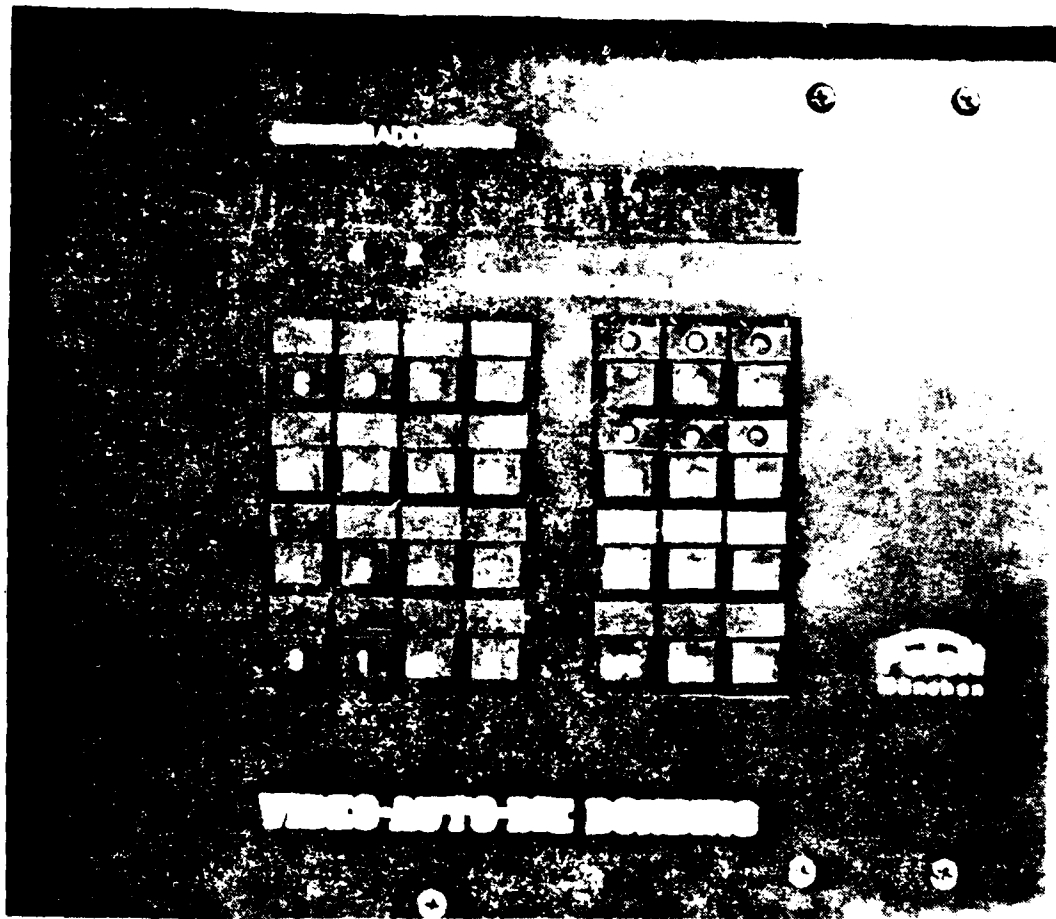


FIGURE 1

PROGRAM, SERVICE & OPERATOR KEY BOARD

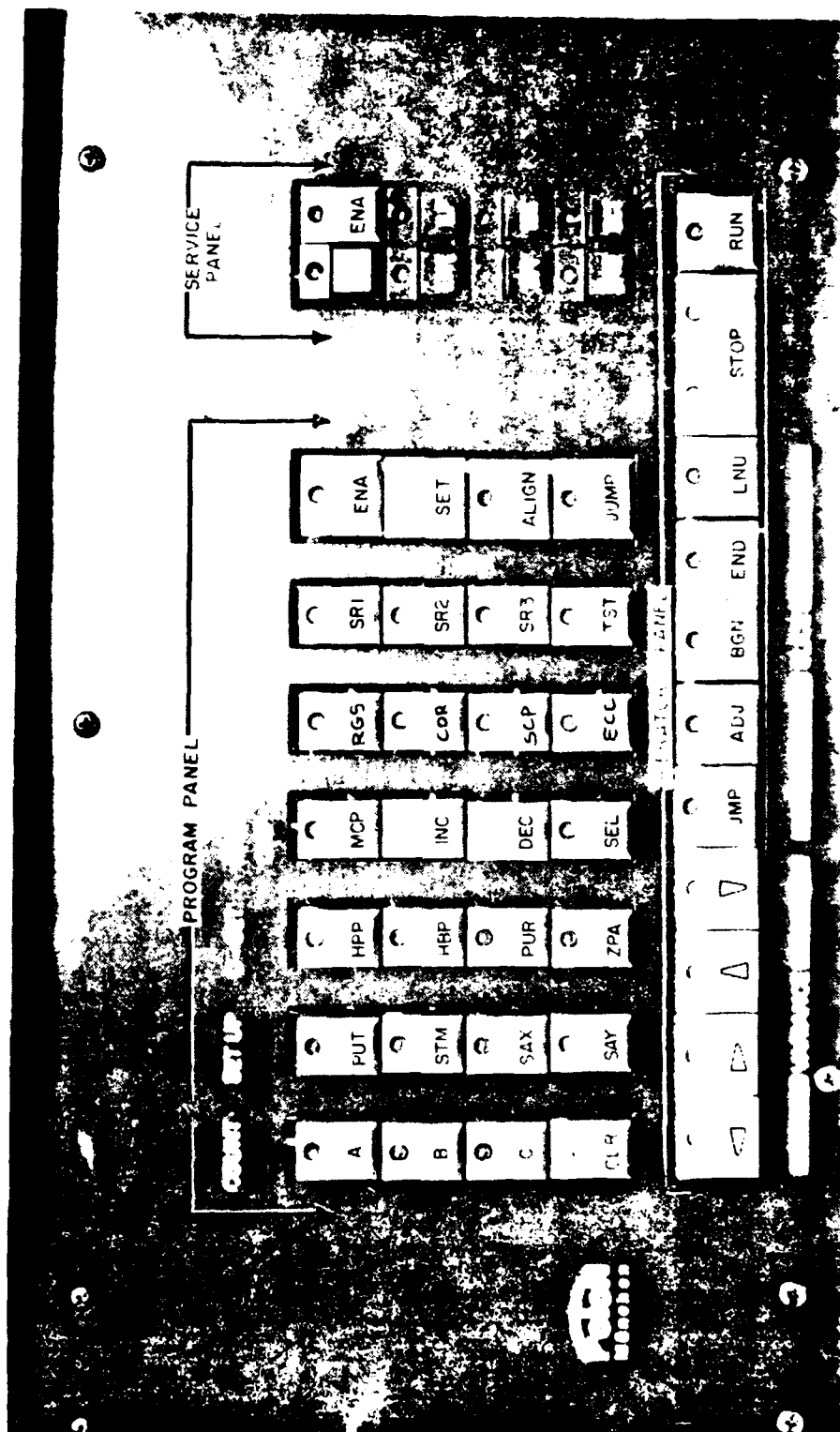
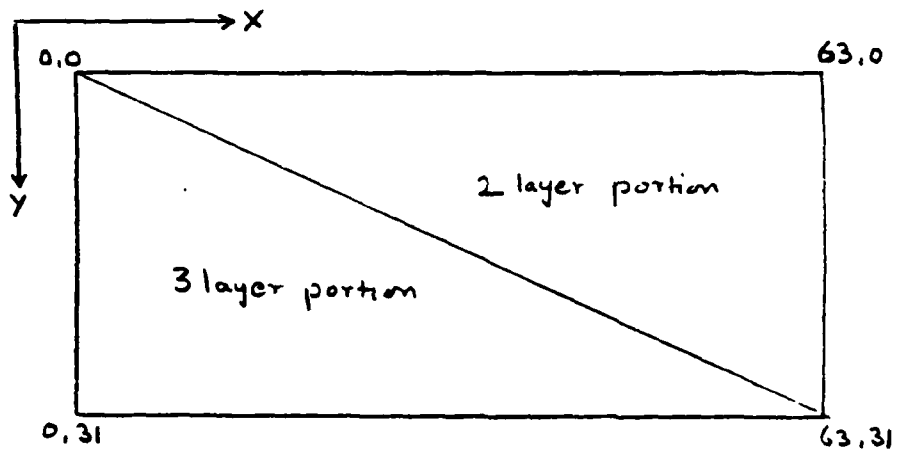


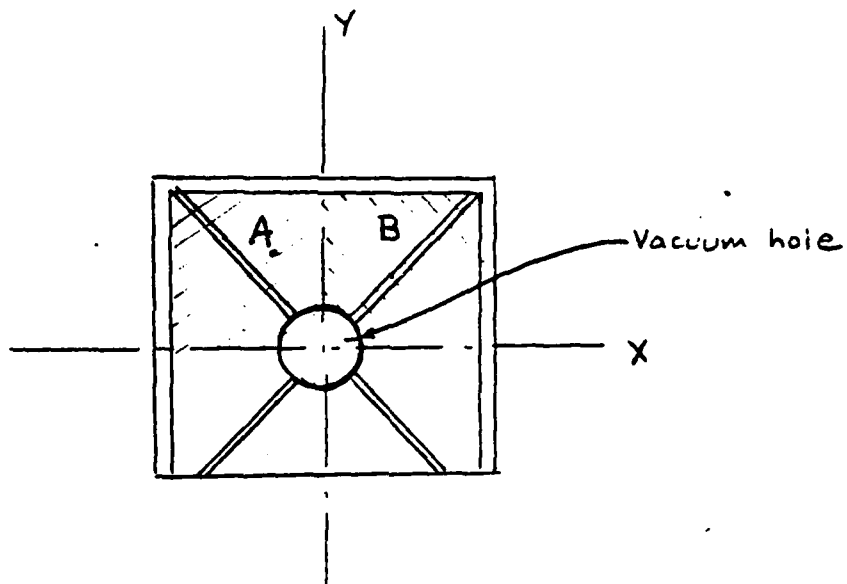
FIGURE 3

FIGURE 4.



FOTON Machine Co-ordinates for Individual die
placements for Litton Display Program.

FIGURE 5



DIE COLLETT BOTTOM.

NOTE - Die Collett is 3 sided only. For Collett adjustment on TV screen, make areas A and B exactly square.

710819L

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED

**INTERPRET THIS DRAWING
PER STANDARDS IN
MIL-STD-100**

**UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE
IN INCHES**

DECIMAL
 .XX ± .01
 .XXX ± .005
 FRACTIONS ± 1/64
 ANGULAR ± 0°30'

✓

Contract Number	
APPROVALS	DATE
Prep. <i>[Signature]</i>	7/24/80
Check	
Proc. Eng. <i>[Signature]</i>	7/24/80
Elect. Eng.	
Mfg. Eng.	
Qual. Eng.	
Reliability	
Proj. Office <i>[Signature]</i>	

TELEDYNE MICROELECTRONICS
LOS ANGELES, CALIFORNIA

AUTOMATIC THERMOSONIC WIRE BONDING

WP

SIZE A	CODE IDENT. NO. 16170	DRAWING NO. 7108158
SCALE	REV	SHEET

101-1
1 of 20

1. SCOPE
 - 1.1 This document describes the operating procedure for Hughes Model HM1460 Microcomputer Wire Bonder.
 - 1.2 TM 7107557 may be used as an alternate for this process.
2. APPLICABLE DOCUMENTS
 - 2.1 Instruction Manual for Hughes Model HM1460 Microcomputer Wire Bonder
 - 2.2 Applicable Layout Drawings
 - 2.3 JI 6.177, Lead Bond Pull Test
 - 2.4 TM 7107557, Gold Wire Ball Bonding
3. EQUIPMENT AND SUPPLIES REQUIRED
 - 3.1 Hughes Model HMC1460 Microcomputer Wire Bonder
 - 3.2 Capillary Unplugging Tool
 - 3.3 115 Volt, 60 Cycle, 20 Amp AC Outlet
 - 3.4 Vacuum, Plant Line
 - 3.5 Nitrogen, Plant Line, TM 7250308
 - 3.6 Capillary, TM 7104502
 - 3.7 Wire, Gold, TM 7250223 (reference applicable assembly drawing)
 - 3.8 Dummy hybrid for setup as required
 - 3.9 Finger Cots
 - 3.10 Face Mask
 - 3.11 Isopropyl Alcohol, TM 7250270
 - 3.12 Thermocouple Bridge with applicable Thermocouple
 - 3.13 Floppy Discs

SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	7108158
SCALE	REV	SHEET 2

4. SAFETY PRECAUTIONS

4.1 The bonding stage is hot and should not be touched.

4.2 To prevent electrical shock, do not touch bonding wire while actuating the "Electronic Flame-off Torch".

5. PROCESS PREPARATION

5.1 Machine Setup

NOTE: Performed by manufacturing service

5.1.1 Inspect capillary under 40 to 60X magnification for defects such as chips, plugged hole or excessive wear. If a defect is suspected, verify at 100 to 400X. Reference 7104502 for correct capillary/configuration.

5.1.2 Unplug capillaries as required (ref. 3.2).

5.1.3 Ensure capillary vial is identified per 7104502. Install capillary on machine and enter all pertinent information in "Lead Bond Maintenance Log" (ref. applicable tooling matrix).

5.1.4 Target Spotlight Offset

Refer to Section 3.4.8.1 of Hughes HM1460 Owner's Manual.

5.1.5 Bond Height Adjustment

CAUTION: Be sure that, at its lowest point, the capillary is above the work stage. Otherwise the stage may strike the capillary and break or damage it.

5.1.5.1 Move the substrate tooling from underneath the bond arm.

5.1.5.2 Actuate the "hockey puck" switch or BOND button on the console and cycle the bonder through a complete cycle from Reset through First Bond, Loop, Second Bond and back to Reset.

5.1.5.3 Put the bonder in the SETUP mode and cycle the bonder to the first bond position.

5.1.5.4 With the bond arm in first bond position, lower the substrate holder so that there is sufficient clearance for the substrate to be moved under the capillary without touching. Find the lowest bonding point on the substrate to be bonded and move it directly under the capillary. (NOTE: This should be done without wire in the capillary.) Raise the heated substrate holder until the lowest point to be bonded on the substrate just touches the capillary. Raise the substrate holder .010 inches. This will set the initial bond height.

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5.1.6 Wire Spool Loading

NOTE: Use finger cots for the following steps:

- 5.1.6.1 Remove the glass cover from the spool holder.
- 5.1.6.2 Remove the wire run off ring. Use the end of a pair of tweezers and unscrew the ring.
- 5.1.6.3 Place the single-flanged wire spool on the spool holder with the flange to the back.
- 5.1.6.4 Hold the wire run off ring by the center mounting stud on back and clean the outer ring surface with a lint-free cloth and isopropyl alcohol.
- 5.1.6.5 Replace the wire run off ring.
- 5.1.6.6 Using tweezers, break wire from spool at red dot. Draw out a piece of wire approximately 8 inches long.
- 5.1.6.7 Lead the free wire end through the feed hole in the glass cover.
- 5.1.6.8 Replace the glass cover.
- 5.1.6.9 Place the wire spool holder on the bonder wire spool mount.
- 5.1.7 Threading the Wire Feed
- 5.1.7.1 Cycle the bonder to Loop.
- 5.1.7.2 Thread the wire end through the wire guide track.
- 5.1.7.3 Draw the wire between the tension pads.
- 5.1.7.4 Draw the wire between the arms of the air fork.
- 5.1.7.5 Insert the wire end through the upper guide tube.
- 5.1.7.6 Pull the wire through the upper guide tube, guiding the wire so that it is drawn between the wire clamp jaws.
- 5.1.7.7 Insert the wire end through the capillary.
- 5.1.7.8 Draw the handled wire section free of the capillary.
- 5.1.8 Capillary Installation

Refer to Section 4.12.1 of Hughes HM1460 Owner's Manual.

SIZE A	CODE IDENT NO. 16170	DRAWING NO. 7108158
SCALE	REV	SHEET 4

5.1.9 Electronic Flame Off

Refer to Sections 4.12.3 and 4.7 of Hughes HM1460 Owner's Manual.

5.1.10 Tail Length Adjustment

Refer to Section 4.8 of Hughes HM1460 Owner's Manual.

5.1.11 Wire Tension

Refer to Section 4.9 of Hughes HM1460 Owner's Manual.

5.1.12 First and Second Bond Force

Refer to Section 4.2 of Hughes HM1460 Owner's Manual and Table 1 of this procedure.

5.1.13 First and Second Bond Time

Refer to Section 4.3 of Hughes HM1460 Owner's Manual and Table 1 of this procedure.

5.2 Machine Settings

5.2.1 Set bonding base temperature to $170 \pm 10^{\circ}\text{C}$. Temperature shall be set by manufacturing services utilizing a thermocouple bridge. Thermocouple placement shall be in the horizontal base plate hole, directly below the package location. Base temperature should be checked and logged at the beginning of each working shift on which the machine is used. Reference Table 1 for force (grams) and time (milliseconds) setting for Channel 1 and 2. Power is variable and may be adjusted to obtain optimum lead bond results.

5.3 Machine Start Up from Total Shut Down

NOTE: Refer to Figures 1, 2, 3 and 4 for the location of switches and keys to be used.

5.3.1 Turn on main power switch.

5.3.2 Turn on bonder power, area lights and spotlight.

5.3.3 Press RUN button.

5.3.4 Reset Electronic Flame Off (EFO) switch.

5.3.5 Check bonder status. If the bonder is not in reset position (ready to make ball bond), cycle the bonder to reset position using a hockey puck switch.

5.3.6 Perform spotlight offset (Section 5.1.4).

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A	16170	7108158
SCALE	REV	SHEET
		5

- 5.3.7 Check to make sure capillary is threaded with wire and ball is formed at the tip of capillary. If apillary is not threaded, perform the following:
- 5.3.7.1 Press OFF LINE key. Display will read "OFF LINE".
- 5.3.7.2 Move heated stage from under the capillary using a joystick.
- 5.3.7.3 Cycle the bonder with hockey puck switch to loop position, which opens the wire clamp.
- 5.3.7.4 Thread the capillary while actuating the ultrasonic generator test button, leaving a piece of bent wire protruding from capillary tip.
- 5.3.7.5 Move heated stage with joystick and install and position a bondable portion of dummy substrate under the capillary per Section 6.1. Actuate hockey puck switch and bond off excess wire.
- 5.3.7.6 Press START key to return the bonder to "BONDER SYS 3.1".
- 5.3.8 Make several bonds on dummy substrate using hockey puck switch and joystick after pressing OFF LINE key. Inspect the bonds to make sure they meet necessary visual requirements. Press START key to return the bonder to "BONDER SYS 3.1".
- 5.3.9 Perform pull test (see Section 7.1).
- 5.4 Machine Start Up from Stand-by Condition
- Perform all of the operations indicated in Section 5.3 except Section 5.3.1 and Section 5.3.6.
- 5.5 Set the Bonder to Stand-by
- The bonder should be placed in stand-by whenever the machine will not be used for more than 2 hours.
- Step 1. Turn off bonder power.
- Step 2. Turn off spotlight.
- 5.6 Operator Control Key Functions
- See Figure 2.
- 5.6.1 START
- The START key initiates an operation—for example, starting a program--or executes the command shown on the display.

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		6

5.6.2 STOP

When the STOP key is pressed, AUTO (automatic) mode operations are halted immediately following the current bond operation. If the bonder is between ball and stitch, the current wire will not be completed..

5.6.3 BOND

The BOND key is used in conjunction with the STEP mode and OFF LINE mode control keys. If the BOND key is on while in STEP mode, the programmed bond is actually made. If BOND is off, then the point to be bonded is positioned under the spotlight and only visual inspection is allowed. In OFF LINE, pressing the BOND key causes one bond operation to take place, either ball or stitch, independent of programmed locations.

5.6.4 WIRE

On pressing WIRE #, the display will read "WIRE NO =". When the operator enters the maximum 4-digit wire number and presses START, the bonder goes to the ball bond position of that wire. If the number entered is greater than the number of wires in the currently loaded program, the display will show "PROGRAM END" and the table will move to the last ball position. If, on pressing the WIRE # key "ILLEGAL COMMAND" appears on the display, the wire number is invalid at that time. The operator must then press CLR DISP (clear display) to clear the error condition.

5.6.5 BACK WIRE

The BACK WIRE key is like the backspace key on a typewriter in that it resets the program and XY table to the ball bond position of the previous wire. BACK WIRE is valid during STEP mode. During STEP, BACK WIRE allows inspection of the previous ball location. In either mode with the BOND key light on, BACK WIRE will allow a bond to be made only at the ball position. Bonding and visual inspection at stitch locations cannot be done with the BACK WIRE key. To do so, the STEP key must be used.

5.6.6 CLR DISP

The CLR DISP (clear display) key has several functions, depending on the mode of operation. If an error is displayed to the operator, the CLR DISP key must be pressed to clear the error condition, followed by START to continue execution. Should the operator make an error on a numeric entry, pressing the CLR DISP key will erase the entry so that it can be re-entered correctly.

5.6.7 ABRT PROG

ABRT PROG (abort program) key is used to terminate the entry or operation of a program. The operator may then re-start the program from the beginning

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or perform PR 'TR (program enter), PROG LOAD (program load),
PROG SAVE (p. n save), or TEST mode functions.

During PROG ENTR (program enter), pressing the ABRT PROG key will terminate the program and cause "PROGRAM END" to be displayed. Then, pressing START will return the system to the start of the program, indicated by "BONDER SYS 3.1" on the display. ABRT PROG will also terminate operation under STEP or AUTO control, returning the system and display to "BONDER SYS 3.1".

ABRT PROG is valid only during STEP mode, and only prior to a ball; never prior to a stitch. If pressed at any other time, "ILLEGAL COMMAND" will be displayed. CLR DISP must then be pressed to clear the error condition.

During AUTO operation, pressing ABRT PROG will have no effect. STOP must first be pressed to halt machine cycling, followed by ABRT PROG to return the display to "BONDER SYS 3.1".

5.6.8 ZERO TABLE

ZERO TABLE key is used primarily for initial setup and, when pressed, brings the work table to "home" position. From the operator's viewing point, this position is full table travel in the extreme left and extreme downward position.

5.6.9 AUTO

When a program is resident in memory, the operator may initiate operation in the automatic mode by pressing the AUTO (automatic) key. This means that, if the AUTO key is activated, automatic bonding will begin immediately following acceptance of the final reference point. These reference points are individually aligned and accepted with the joystick, target light and START key.

5.6.10 STEP

The STEP mode key allows the operator to execute the program one operation at a time. The substrate, die, and absolute bond points will be referenced as in the AUTO mode. However, the bond locations will be stepped through in one of two ways determined by the operator: if the BOND key light is off, each bond point will be positioned under the spotlight for visual inspection only, and all pertinent information will appear on the display. The operator may then step to the next operation by pressing the START key. If the BOND key light is on, each bond point is positioned under the capillary and then the bond is actually made. Again, the operator may step to the next operation by pressing the START key.

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SCALE	REV	SHEET
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Stepping through the wire locations is possible without continually pressing the START key if the automatic STEP capability is used. Rather than pressing START after the STEP key is pressed, press TEST instead. The XY table will move to the first substrate reference and through all successive references and absolute bonds just as it would for manual STEP--these must be individually accepted with the START key (or skipped by pressing numeric 9). However, when the final reference is entered, the bonder will automatically step through all the wire locations with no further operator intervention. The automatic STEP operation can be halted by pressing STOP, then re-started by pressing START.

5.6.11

OFF LINE

CAUTION: Be sure work stage is clear of bonder chassis before using this key. Otherwise, the stage may strike the chassis.

When the OFF LINE key is pressed, the display shows "OFF LINE" and the operator can move the XY table with the joystick. If the BOND key is pressed while in OFF LINE mode, either a ball or stitch will be made depending upon which is next in sequence. No adjustment is made for the spotlight offset.

On pressing the START key, the XY table will automatically return to its previous position; that is, the position it was in prior to the OFF LINE mode command. At the same time, the display will also show the previous message.

Should the operator wish to position the XY table to any corner, OFF LINE mode has the capability to do so without requiring use of the joystick. By pressing numeric 0 after OFF LINE, the table is moved to the extreme left and forward (0,0) position. Likewise, pressing 1 will move the table to the extreme left and back, 2 will move it to the extreme right and back, and 3 will move it to the extreme right and forward. This feature offers the advantage of moving the XY table to a convenient position without use of the joystick, thus eliminating the possibility of reaching the X or Y table limits.

6.0

Operational Procedure

- NOTE:**
1. For clarity, display messages are written with quotation marks. Keys to be pressed are underlined.
 2. Refer to Section 6.7 of this document for reference location.

6.1

"BONDER SYS 3.1"

Insert floppy disc for the circuit to be run into the floppy disc drive in the direction indicated by the arrow on the disc and close the door. Press the INITIALIZE DISC button located just below the disc loading slot (see

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SCALE	REV	SHEET
		9

Figure 1) and wait 5 seconds for disc drive to come to speed. Floppy disc covers have appropriate subassembly number prefixed by 4LB (e.g. 4LB2271234) and disc revision letter inscribed on them.

NOTE: Do not touch or attempt to clean disc surface. Keep disc away from heat, dust and magnetic fields.

6.2 PROG LOAD

"LOAD XXXXXXXX"

Part number of hybrid appears where noted with seven X's on display. If this is the part number the operator wants to load, pressing START key begins transfer of the program from the disc to memory. If the operator does not wish to load this program, ABRT PROG (abort program) key is pressed and "BONDER SYS 3.1" is again displayed.

When transfer of the program is completed, "BONDER SYS 3.1" will appear on display.

6.3 Load the hybrid securely on heated work stage, making sure it is orientated according to appropriate subassembly drawing while depressing heated stage vacuum button (Figure 3) to release vacuum and enable hybrid movement.

Adjust microscope so that the spotlight is in view.

6.4 Press STEP key and then BOND key. (If AUTO key is pressed instead of STEP key, the machine will begin automatic placement following acceptance of final die reference.)

"PROG XXXXXXXX"

6.5 Perform the following sequence for entering all reference points. See Section 6.7 for pertinent reference point locations.

6.5.1 START

"SUBSTRATE 1 REF 1"

Move joystick and locate spotlight to first substrate reference location.

6.5.2 START

"SUBSTRATE 1 REF 2"

Adjust joystick to second substrate reference location.

6.5.3 START

"DIE 01 REF 1"

Adjust joystick and locate spotlight to first die reference location of first die.

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6.5.4 START

"DIE 01 REF 2"

Adjust joystick to second reference location of first die.

6.5.5 START

"DIE 02 REF 1"

Adjust joystick and locate spotlight to first reference location of second die.

6.5.6 START

"DIE 02 REF 2"

Adjust joystick and locate spotlight to second reference location of second die.

6.5.7 START

Alignment of die reference position continues until all of the remaining dice have been checked and adjusted.

NOTE: Absolute bond (ABS BOND) is used whenever reference location also serves as bond location (i.e., Transistors and Diodes). Consult applicable subassembly drawing.

6.6 Bonding Operation

"W001 DIE 01/B" (Wire #1, Die #1, Ball Bond Position)

Adjust microscope so that the area where first bond to be made is in view.

6.6.1 START

First bond is made.

"W001 SUB/S" (Wire #1, Substrate, Stitch Bond Position)

6.6.2 START

Second bond is made.

6.6.3 If bond positioning is acceptable, press AUTO and then START key.

NOTE: It is permissible to go into auto bonding sequence instead of step sequence immediately after entering reference points. The step sequence is only intended to verify that the whole system is satisfactory to run.

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SCALE	REV	SHEET
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6.6.4 If bond positioning is not acceptable, press ABRT PROG (abort program) key and repeat Section 6.5.

6.6.5 Make sure that the bond positioning, bond shape, bond dimension and wire loop height meet specifications. Press STEP key to stop bonding if an irregularity is noticed. Correct the problem. Press AUTO and START to resume bonding.

NOTE: It should be noted that OFF LINE, WIRE # and BACK WIRE functions will not be available if STOP key was used to stop the bonder.

6.6.6 "PROG XXXXXXXX" will reappear on the display upon completion of automatic bonding cycle. The next substrate may be loaded now, or the ABRT PROG key pressed and a new program loaded.

NOTE: It is not uncommon to have a few loose stitch (wedge) bonds. Perform rework using a manual lead bonder per 7107557 procedure.

6.7 Reference Locations, Wire and Die Numbers

6.7.1 SUBSTRATE REFERENCE (2 locations per substrate)

Refer to appropriate subassembly drawing for the exact locations of substrate reference to be used.

6.7.2 DIE REFERENCE (2 locations per die)

Refer to appropriate die geometry document for the exact locations of die reference to be used.

NOTE: Typically, first reference location is located at upper left corner of corner pad of substrate or die and second reference location is located at lower right corner of corner pad of substrate or die.

6.7.3 WIRE AND DIE NUMBER

The wire number begins with 1 and increases in numerical order. It does not return to 1 when the die changes. Likewise, dice are also numbered consecutively. Die numbers and wire number sequences are shown on the subassembly for reference purposes.

6.8 Display Error Message and Corrective Action

6.8.1 "AT TABLE LIMIT X" (OR Y)

This message indicates that the table was moved to its X or Y movement limit. To clear the error and free the keyboard, press CLR DISP key (clear display—see Section 5.6.6).

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SCALE	REV	SHEET
		12

6.8.2 "ILLEGAL COMMAND"

This message indicates that the key pressed is invalid at that time. Press CLR DISP to clear the error condition.

6.8.3 "DISC ERROR"

This message indicates that the floppy disc was inserted or started incorrectly. Remove disc from disc drive, press CLR DISP key and reload.

6.8.4 "CHECK JOYSTICK"

This message indicates that the joystick was being moved while START key was pressed. To clear the error and free the keyboard, move the adjustment tabs located immediately above and to the right of the joystick until both directional indicator lamps go out (Figure 2). Press CLR DISP.

6.8.5 "NO LIGHT OFFSET"

This message indicates that target spotlight offset is not in memory. Press CLR DISP and perform Section 5.1.4.

6.8.6 "MACHINE NOT READY"

This message indicates that the bonder section of system needs adjustment. Call manufacturing service technician or process engineer assigned to the area.

6.8.7 "PROTECT KEY ON"

This message indicates that unauthorized operator entry was made. Press CLR DISP.

6.8.8 "PROG NOT IN MEMORY"

This indicates that the program is not stored in the machine. Press CLR DISP and perform program load of Sections 6.1 and 6.2.

6.8.9 "BONDER PHASE ERROR"

This message indicates that the bonder and the microprocessor are not syn-chronized. Adjust the bonder status by actuating hockey puck switch and cycle the bonder to next position. Press CLR DISP.

6.8.10 "NO FLAME OFF"

If this message appears after bonder power was turned on and ball was observed under the capillary, press EFO reset button (Figure 3), press CLR DISP and proceed. If this message appears during bonding, it indicates that the ball

SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	7108158
SCALE	REV	SHEET
		13

is not formed at tip of the capillary and that the capillary needs to be rethreaded. Press CLR DISP key and the STEP key (if the machine is in auto mode). Press OFF LINE key and adjust joystick so that the heated stage is moved away from bonding tool. Actuate the hockey puck switch and cycle the bonder to "LOOP" position. Rethread the capillary while pressing ultrasonic generator "TEST" button. When capillary is rethreaded, adjust joystick moving heated stage so that the unused metallization of circuit is under the capillary. Bond off excess wire. Press START key and proceed.

6.8.11 Bonding of Missing Wire(s)

6.8.11.1 Stop bonding sequence by pressing STEP key.

6.8.11.2 Press OFF LINE key.

6.8.11.3 Press SPEC FTN (special function) key. "SPOTLIGHT BALL" will appear on the display.

6.8.11.4 Adjust the microscope so that the spotlight is in view. Position the spotlight to first bond location with joystick.

6.8.11.5 Press START key. "SPOTLIGHT STITCH" will appear on the display.

6.8.11.6 Position the spotlight to second bond location with joystick. Press START key to automatically place the wire.

Repeat Step 6.8.11.4 through Step 6.8.11.6 until all the missing wires are placed.

6.8.11.7 To terminate the missing wire operation, press ABRT PROG key and then START key. The bonder will automatically return to the original location and the program can be resumed.

6.8.12 Bonding of Missing Wire(s) - Alternate Method

6.8.12.1 Stop automatic bonding by pressing STEP key.

6.8.12.2 Press WIRE # key. The display will read "WIRE NO".

6.8.12.3 Press number key(s) and enter desired wire number to be placed (refer to appropriate subassembly drawing for appropriate wire number to use).

6.8.12.4 Press START key to make first bond.

Press START key again to make second bond.

Repeat Step 6.8.12.2 through Step 6.8.12.4 until all the missing wires are placed.

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SCALE	REV	SHEET 14

6.8.12.5 To terminate the missing wire operation, press WIRE # key and enter original wire number location and the program can be resumed.

6.8.13 Wire Placement for Replaced Die (or Dice)

Perform all of the operations indicated in Sections 6.1 through 6.6 of this procedure except that the die reference locations that do not require wire placement will be skipped by pressing NO OPER (no operation) key.

CAUTION: To prevent wire placement on top of the existing wires, do not perform die reference on dice that already have wires.

7.0 SPECIAL PROVISIONS

7.1 Lead Bond Pull Test

Twenty-five loops shall be bonded on sample substrate in accordance with JI 6.177. The distance between bonds shall be approximately twice the height of the loop and wires should be spaced approximately .025 inch apart. This operation can be performed using "Pull Test Floppy Disc" or manually (press OFF LINE key and use hockey puck to actuate the bonder and joystick to move the pull test substrate).

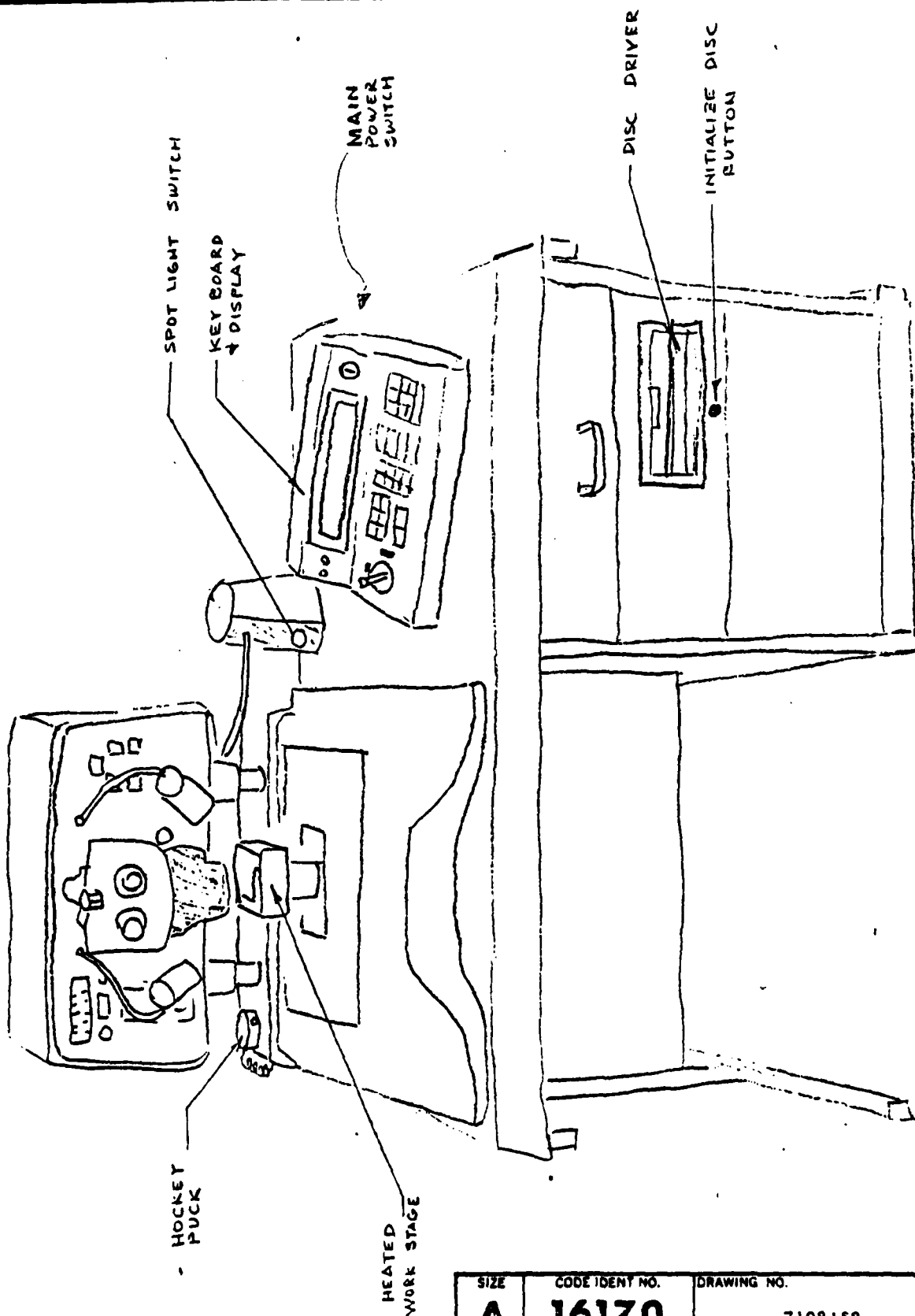
7.2 Lead Bond Pull Test shall be performed in accordance with JI 6.177.

SIZE A	CODE IDENT NO. 16170	DRAWING NO. 7108158
SCALE	REV	SHEET 15

<u>Wire Size</u>	<u>Channel 1 Force/Wt. (Grams)</u>	<u>Channel 1 Weld Time (Milliseconds)</u>	<u>Channel 2 Force/Wt. (Grams)</u>	<u>Channel 2 Weld Time (Milliseconds)</u>
.001 Inch Diameter	40 ± 15	40 to 80	60 ± 20	40 to 100

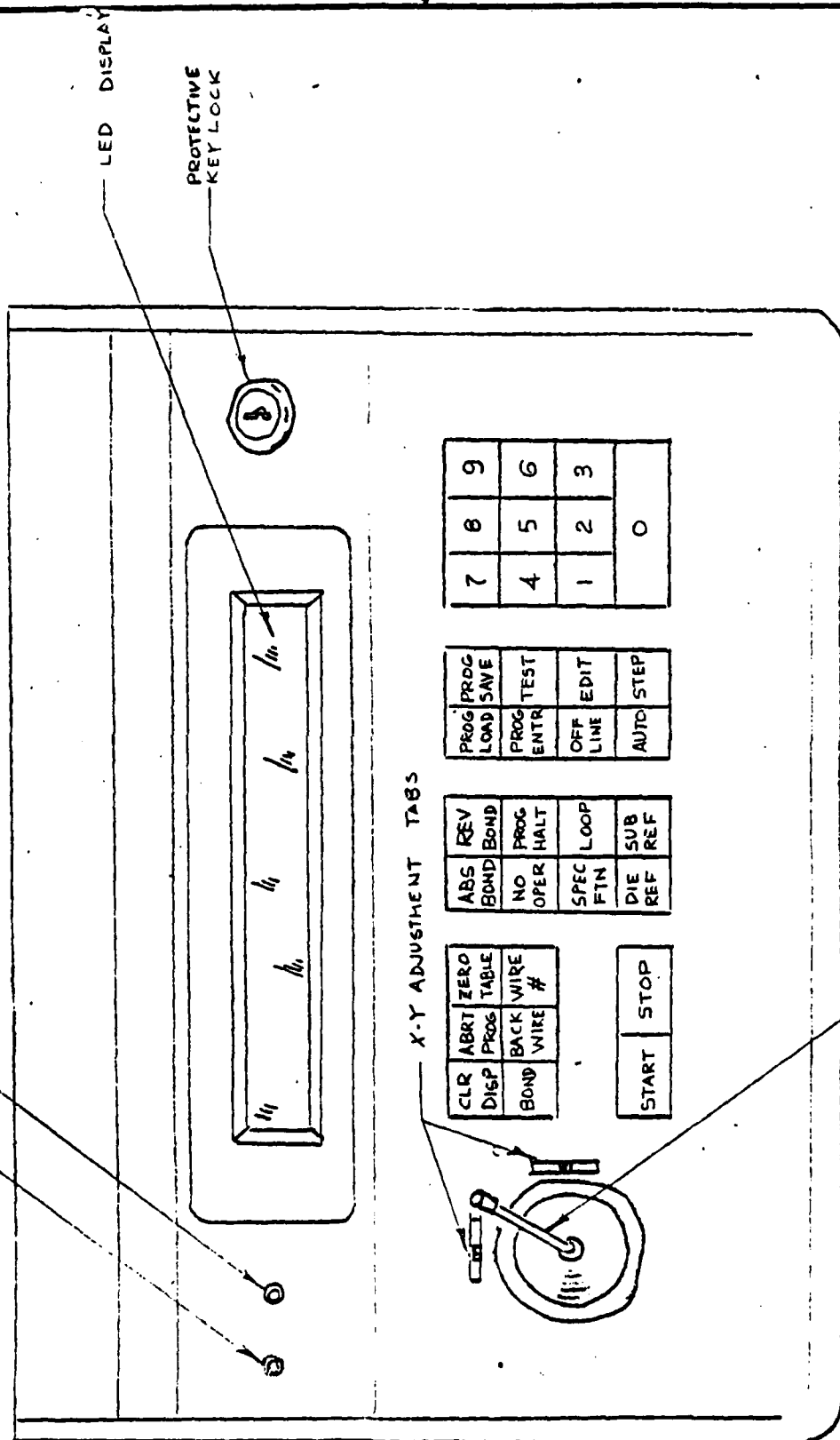
TABLE 1

SIZE A	CODE IDENT NO. 16170	DRAWING NO. 7108158
SCALE	REV	SHEET 16



SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	7108158
SCALE	REV	SHEET
		17

Y DIRECTION INDICATOR
X DIRECTION INDICATOR



SIZE A	CODE IDENT NO. 16170	DRAWING NO. 7108158
SCALE	REV	SHEET 18

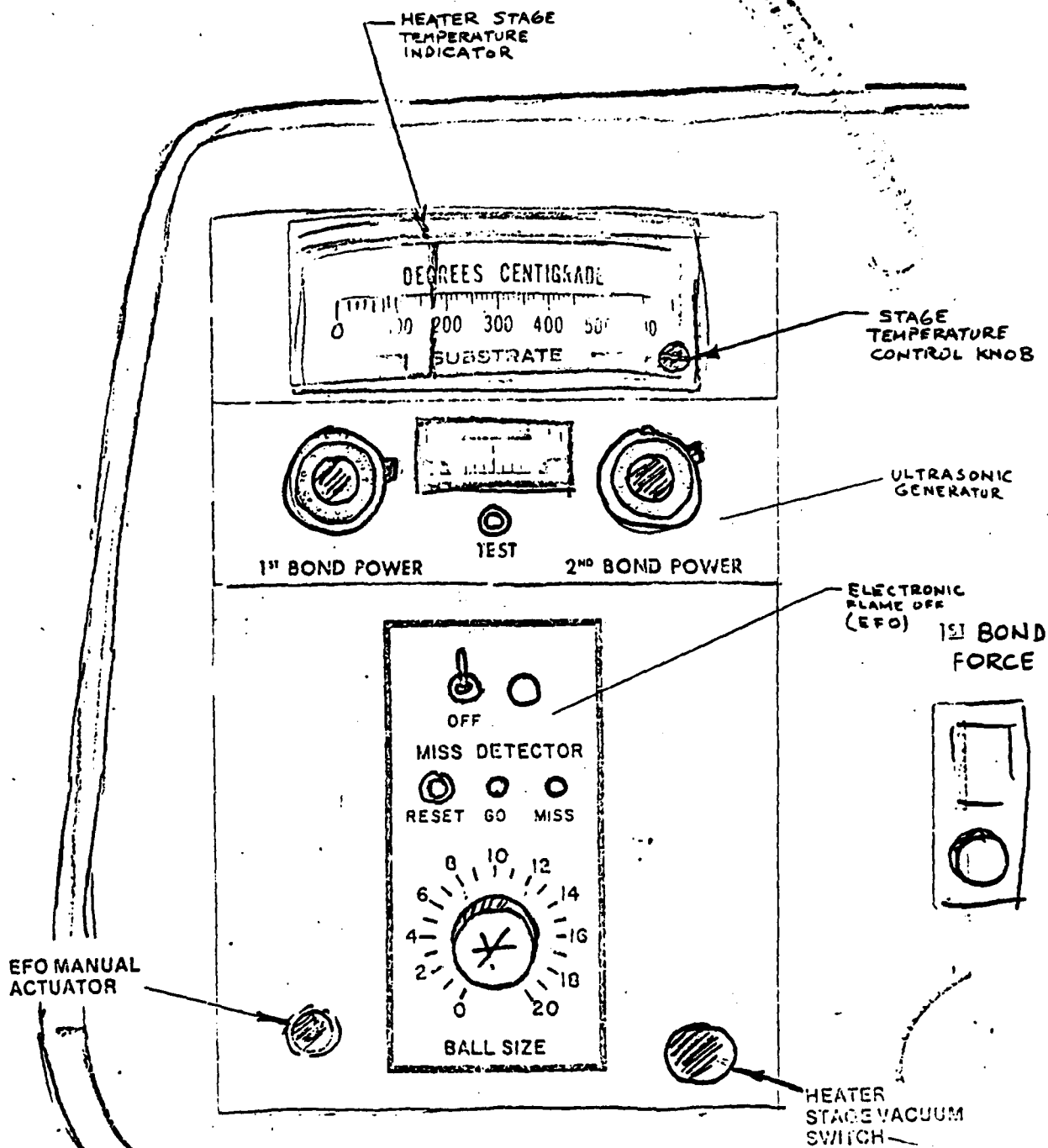


FIGURE 3
BONDER CONTROLS (LEFT SIDE)

SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	7108158
SCALE	REV	SHEET
		19

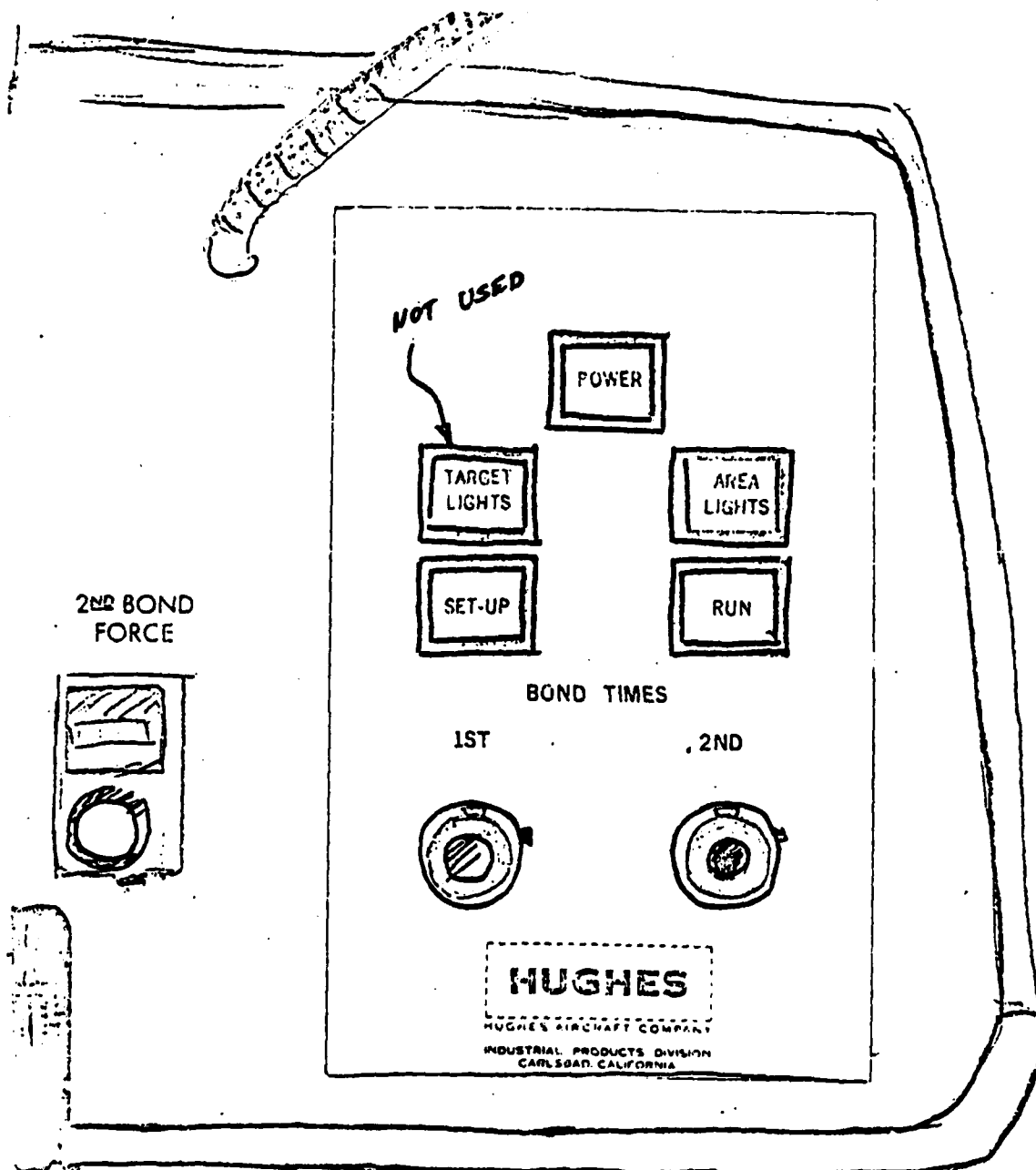


FIGURE 4
BONDER CONTROLS (RIGHT SIDE)

SIZE	CODE IDENT. NO.	DRAWING NO.
A	16170	7108158
SCALE	REV	SHEET
		20

[illegible]

1. SCOPE
 - 1.1 This process describes the operation of lens attach and encapsulation of LED displays with collimators (lenses).
2. APPLICABLE DOCUMENTS
 - 2.1 Spray Clearing, TM 7107369
3. EQUIPMENT AND SUPPLIES REQUIRED
 - 3.1 Substrate Holding Fixture
 - 3.2 Teflon Insert
 - 3.3 Applicable Collimators
 - 3.4 Optical Grade Epoxy, Epotek 301-2, Premixed and Maintained at -40°C , TM 7258836
 - 3.5 Dry Release Agent MS-122, Emerson and Cumings
 - 3.6 Oven Set to Maintain $80 \pm 5^{\circ}\text{C}$
 - 3.7 Eye Dropper
 - 3.8 Knife Edge Fixture with Back Plate
 - 3.9 Two Pound Weight
 - 3.10 X-acto Knife
 - 3.11 Grinding Fixture
 - 3.12 Surface Grinder
 - 3.13 Polisher, Coburn Model 901 or Equivalent
 - 3.14 Polishing Cloths, Buehler Catalog No. 40-7622 or Equivalent
 - 3.15 Alumina Polishing Compound, 1.0 Micron
 - 3.16 Tap Water
 - 3.17 Kimwipes
 - 3.18 Sine Bar

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A	16170	7108159
SCALE	REV	SHEET
		2

3.19 Hypodermic Needle No. 18 and Syringe

3.20 Vacuum Pump and Tubing

3.21 Solder Mask

3.22 Deionized Water, TM 7250319

4. SAFETY PRECAUTIONS

4.1 Oven is hot. Handle parts coming out of the oven carefully.

4.2 The polisher works at high speeds. Use it with extreme care.

5. PROCESS PREPARATION

5.1 Epoxy Setup

5.1.1 Remove epoxy from cold storage and allow to attain room temperature.

5.2 Oven Setup

5.2.1 Turn on oven and set to maintain $80 \pm 5^\circ \text{C}$.

5.3 Polisher Setup

5.3.1 Load polishing cloth on the rotary platform of the polisher. Pour small amount of DI water and add alumina compound on the cloth. Let the compound spread evenly over the polishing cloth.

5.4 Surface Grinder Setup

NOTE: The surface grinder shall be operated by an experienced machinist only. For top surface grinding, the LED display substrate with holding fixture will be placed on the grinder table directly. For edge grinding, an appropriate sine bar shall be used.

6. OPERATIONAL PROCEDURE

6.1 Potting Fixture Preparation

6.1.1 Spray release agent on all parts of the substrate fixture.

6.1.2 Apply a bead of solder mask around the guide pins of teflon insert.

6.1.3 Put teflon insert on the substrate fixture.

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A	16170	7108159
SCALE	REV	SHEET
		3

3.1.9 Hypodermic Needle No. 18 and Syringe

3.2.0 Vacuum Pump and Tubing

3.2.1 Solder Mask

3.2.2 Deionized Water, TM 7250319

4. SAFETY PRECAUTIONS

4.1 Oven is hot. Handle parts coming out of the oven carefully.

4.2 The polisher works at high speeds. Use it with extreme care.

5. PROCESS PREPARATION

5.1 Epoxy Setup

5.1.1 Remove epoxy from cold storage and allow to attain room temperature.

5.2 Oven Setup

5.2.1 Turn on oven and set to maintain $80 \pm 5^\circ \text{C}$.

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5.3.1 Load polishing cloth on the rotary platform of the polisher. Pour small amount of DI water and add alumina compound on the cloth. Let the compound spread evenly over the polishing cloth.

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NOTE: The surface grinder shall be operated by an experienced machinist only. For top surface grinding, the LED display substrate with holding fixture will be placed on the grinder table directly. For edge grinding, an appropriate sine bar shall be used.

6. OPERATIONAL PROCEDURE

6.1 Potting Fixture Preparation

6.1.1 Spray release agent on all parts of the substrate fixture.

6.1.2 Apply a bead of solder mask around the guide pins of teflon insert.

6.1.3 Put teflon insert on the substrate fixture.

SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	7108159
SCALE	REV	SHEET
		3

- 6.1.4 Apply a bead of solder mask around the cavity on the second step in the teflon insert where it comes in contact with the substrate.
- 6.1.5 Load the die attached and bonded substrate onto the teflon insert, making sure that the edge devices on the substrate are not damaged.
- 6.1.6 Using X-acto knife and taking extreme care to avoid damage to the display, seat the display substrate firmly into the teflon cavity.
- 6.1.7 Push the corner clip on the fixture against the substrate and tighten the screw to complete substrate loading.
- 6.1.8 Apply solder mask on the corner clip and screw to avoid epoxy attachment on those areas.
- 6.1.9 Apply solder mask to the bottom of the substrate area where it comes in contact with the teflon insert.
- 6.1.10 Place the entire assembly in the oven for 30 minutes minimum to dry solder mask.
- 6.1.11 After removing the assembly from the oven, place it on the bottom plate with guide pins and spray clean just the top surface of the substrate per TM 7107369.
- 6.1.12 Inspect a collimator to make sure it has no visual defects such as blocked pixels, warpage, lack of a reflective surface in the pixels, etc.
- 6.1.13 Spray clean the collimator per 7107369.
- 6.1.14 Carefully load the collimator onto the substrate through the guide pins. Make sure that all the dice and wires are cleared. If any incompatibility is found, return LED substrate for appropriate rework operation.
- 6.1.15 Place the entire assembly with the collimator in oven for 15 minutes minimum.
- 6.2 Epoxy Potting
- 6.2.1 Immediately after removing the assembly from the oven, place it under a microscope; and using eye dropper, inject epoxy into the collimator pixels. Note that the epoxy spreads rather quickly because the assembly is quite hot at this stage.
- 6.2.2 Look for bubbles in the collimator pixels. If a bubble is found, use a hypodermic needle and syringe connected to a vacuum pump to remove the bubble.
- 6.2.3 When the epoxy application is done satisfactorily, place the knife edge fixture with a top plate and the weight on top of the display substrate and collimator assembly.

SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	7108159
SCALE	REV	SHEET
		4

- 6.2.4 Place the entire assembly, knife edge fixture and weights in the oven for 4 hours minimum.
- 6.2.5 Remove assembly from the oven. Remove knife edge fixture along with the top plate and weight. Remove corner clamp screws.
- 6.2.6 Using X-acto knife, release the gap between the metallic substrate fixture and the teflon insert very carefully. Then remove substrate fixture.
- 6.2.7 By gently bending the teflon insert, the substrate can now be separated.
- 6.2.8 Wash potted substrate in running tap water.

6.3 Grinding and Polishing

NOTE: All grinding shall be done by an experienced machinist only.

- 6.3.1 Load the potted substrate on substrate fixture. Using surface grinder, grind the top surface of substrate down to the required thickness.
- 6.3.2 Polish the surface of the substrate on the polisher loaded with 1.0 micron alumina compound. Apply even pressure on the substrate.
- 6.3.3 Stop polishing as soon as the surface shows sharp reflection of light incident on it. Make sure all the scratches caused by the grinder are removed.
- 6.3.4 Using surface grinder, sine bar and other instrumentation, grind the edges of the substrate to the required dimensions per applicable subassembly drawing.
- 6.3.5 Clean unit in running tap water, followed by a DI water rinse and an alcohol spray clean per TM 7107369.
- 6.3.6 Forward unit to the next operation.

7. SPECIAL PROVISIONS

- 7.1 Polishing cloth has to be frequently loaded with additional alumina compound to maintain an acceptable rate of polishing. Replace polishing cloth whenever the nap shows noticeable wear.
- 7.2 Pot life of the optical grade epoxy is about 12 hours. Any epoxy left at room temperature beyond allowable pot life shall be discarded.

SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	7108159
SCALE	REV	SHEET
		5

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TELEDYNE MICROELECTRONICS LOS ANGELES CA

F/G 9/1

MM/T PROGRAM FOR THREE COLOR LIGHT EMITTING DIODE DISPLAY MODUL--ETC(U)

OCT 81 R F DAVID, G W LEWIS

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U.S. GOVERNMENT PRINTING OFFICE: 1967

APPENDIX C

TRIP REPORTS



TELEDYNE

MEMORANDUM

NO: RFR:81-001

TO: File

DATE: 25 FEB 81

FROM: R. F. Redemske

SUBJECT: Visit to NEC LED Facilities on
January 26 & 27, 1981

REFERENCE:

NEC has been the only source for the Red and Green LEDs for the TDS Display Modules. The purpose of the visit was to attempt to resolve the problems of membrane support rings, LED spacing on the membrane and kerf linearity. These factors were found to be important during the fabrication of TDS LED panels using the Foton machine for die attach. The visit was arranged through the local NEC sales representative, Mr. Eugene Murray of Santana Sales.

The visit schedule was as follows:

Sunday, January 25:

Morning flight from Haneda Airport, Tokyo, to Kagoshima, accompanied by Mr. Y. Sugiura of NEC who made the local arrangements, and Mr. Takamura of Teledyne Japan for aid in translation.

Monday, January 26:

Morning train from Kagoshima City to Izumi, the site of the NEC LED device fabrication facility. This plant receives LED wafers from the NEC Tamagawa plant and produces LED lamps, displays and photo couplers. The wafers are first placed on a membrane and sawed almost all the way through. They are then broken and placed on a machine which heats the membrane and expands it to the point of providing about 10 mils spacing between dice. The next step is die attach. The die attach machines are semi-automatic and are manually fed by an operator working from a group of LEDs on a platten. A few newer die attach machines accepted LEDs from a membrane with a pushup needle coordinated with a vacuum pickup collet. An operator still manipulates the wafer for the pickup operation. The rate approached one LED per second which is quite good for manual operation.

The wire bonders were automatic with pattern recognition. In observing the oscilloscope presentation on these machines, the error in LED placement on the post in the lamp structure appeared to be at least ± 3 mils and considerable LED rotation was also evident. However, for the lamp application, this presents no problem.

The LED portion of the visit was completed after observing the automated handling and testing in the fabrication process for the complete lamps. A brief tour of the high volume production facility for fluorescent display panels was the last item on the agenda. This is a vacuum tube type display made in large volume for the automotive industry. It is used there because it provides the brightest display of any technology and can be seen in bright sunlight.

Returned to Tokyo.

Tuesday, January 27:

Visit to Tamagawa plant of NEC at Kawasaki City. This was a one hour taxi ride from central Tokyo.

This large facility includes, among many other things, the group for LEDs and LED displays. In addition, the LED wafers are produced here for shipment to Kagoshima. The basic wafer material is purchased from an outside source, but all processing including diffusions and metallization is done here. However, the wafer mounting on membrane, the sawing and the expanding of the membrane is done at the Kagoshima facility at Izumi.

The first part of the agenda was devoted to engineering discussions. The first question was why we needed Foton type rings for membrane mounting rather than the standard metal NEC rings. The answer was that the 3/4" height dimension of the NEC rings would cause mechanical interference in the Foton machine. NEC understands that problem.

The reason for Teledyne interest in smaller and straighter kerf was discussed. The operation of the Foton machine was reviewed and a model of the TDS module was shown. The basic need for the tight kerf specification is that there is a need to mount the dice within ± 5 microns for the display, while the working accuracy for the NEC lamp fabrication is about 50 to 125 microns. NEC thoroughly understands this. A preliminary specification for the LED and membrane geometry was stated as follows:

- A. The membrane must be mounted on a Foton ring.
- B. Kerf Dimension:

Desirable	3 mils
Maximum	5 mils
- C. Kerf Linearity: No more than 1 mil deviation from straight line per dice position.

Example: For 5 mil kerf allowable angular deviation would be expressed as:

$$\tan \theta = 1/15$$

Teledyne raised the question as to why the membrane is expanded to provide 10 mil spacing between LEDs. The answers are as follows:

- A. It is necessary to perform a visual inspection of the wafer and remove visually defective dice.
- B. It is necessary to remove samples of dice across two perpendicular diagonals of the wafer to determine compliance with the maximum allowed variation in light output of 33%. Twenty (20) dice are removed from each diagonal. The data is plotted in a curve showing light output variation from center to edges, with the edges showing a decreased output. Based on this curve, if the variation is greater than 33%, peripheral dice are removed to the extent necessary to achieve the 33% figure.

- C. A random sample of 20 dice is removed over the area of the wafer and tested to categorize the wafer.

The following questions were raised by Teledyne regarding the above items:

Item A.

1. Why is it necessary to have 10 mil separation to remove visual rejects?

Answer: The dice are removed with a conventional vacuum pickup. The small dice size does not provide enough force to part the LEDs from the membrane, and a side motion is necessary to break the LED loose to accomplish this. This side motion requires the 10 mil separation.

2. Would 5 mil separation be adequate? If it were, the 14 mil LED size artwork could be used and sawed with a wide tool to provide 10 mil dice with a 4 mil kerf. Mounting on a Foton hoop would probably cause a slight stretch to 5 mil separation, which is within the desired limits and would yield very straight kerf due to lack of membrane expansion.

Answer: 5 mil separation is not considered adequate for the removal process. However, it will be looked at again.

3. Why not use a work station with a pushup needle beneath the membrane to force the dice off and coordinate with the vacuum pickup? This principal was observed in operation at the LED attach stations at the NEC Izumi plant in Kagoshima and is also employed in the Foton machine at Teledyne. This action is independent of kerf width and works out very well. It is fairly common in the semiconductor industry.

Answer: A machine of this sort is not presently available to the LED group at the Tamagawa plant.

4. What is the visual criteria which LEDs are considered to be rejected and removed? For such LEDs compared to I.C.s, there should not be a serious visual problem.

Answer: There apparently was no available written criteria. A visit was made to the laboratory to observe an uninspected wafer under a microscope. The visual problems were immediately discernible and consisted of fairly gross phenomena:

Examples:

- (a) Fairly large deep pits or crater type features that normally occur during LED wafer processing.
- (b) Gauge type features where samples of wafer material were removed for analysis.
- (c) Fractures that ran across the wafer independent of saw kerf lines, which grew to fairly large cracks.
- (d) Blank type positions due to deliberate artwork provisions.

The first reaction to this was that the imaging provisions in the Foton machine would possibly reject and pass over dice with these type defects, since they are large with respect to LED dimensions. If this were so, NEC would not have to perform this type inspection. To determine this, NEC will supply a wafer to Teledyne when convenient, to try on the Foton machine to observe its effectiveness in performing this inspection function.

Items B & C:

Why not perform electrical test functions in wafer form before breaking? Dice are sawed almost, but not quite, all the way through. This would leave a gold backing that could be contacted to provide a back contact for test.

Answer: The gold backing used is in the form of four dots and is not continuous.

Why not use a continuous gold backing?

Answer: The dice are bulk emitters and the light emanating downward from the junction will be absorbed at the gold interface, but be reflected where gold is absent. This affects total light output.

Reaction since meeting:

Although this is theoretically correct, the relative areas of gold dots to non-gold areas on a 10 mil die might be re-examined to see how serious the degradation due to a continuous gold layer would be in actual practice.

The following potential needs for LEDs were described as being the best information from Teledyne customer:

1981 - 3.5 million total reds plus greens

1982 - 10 million total

5 year forecast - 100 million total

It was explained that two sources were required, but that this did not necessarily mean a 50-50 split. The vendor with the best price and/or the best product might receive the bulk of the orders. They understand this and are interested in pursuing this program.

As a final statement, NEC pointed out that they would require Teledyne to supply the following equipment in order to produce LEDs to our requirements:

1. Wafer to membrane mounting machine.
2. Foton membrane to hoop mounting machine.
3. Membrane stretching machine.

The reason for Items 1 and 2 was questioned, since such machinery was observed at NEC Kagoshima and further than that, in terms of Item 3, it is desired to eliminate the membrane stretching. It was felt that Item 2 was a reasonable request since the Foton hoop is unique to Teledyne's specific requirement.

The reason for the above is that all the wafers that would be delivered to Teledyne would have to be mounted, sawed and stretched at Kawasaki. This is because there are strict pollution control regulations at the Kagoshima plant that limit the number of gallium arsenide wafers that can be sawed per day. They are presently at that limit so all additional wafers for Teledyne would be processed completely and shipped from Kawasaki. Since the Kawasaki LED operation has no machinery for wafer mounting, etc., machinery would have to be obtained for production operations.

All wafers supplied to Teledyne so far have been shipped from Kawasaki for this reason. The wafer to membrane mounting has been done manually in the Engineering Laboratory, and wafers were sawed there. The wafers were manually stretched due to the lack of machine in the Engineering Lab. Observing this manual process, it becomes very understandable why extensive kerf curvature was present in these wafers. It is probably impossible to maintain linear kerf during a manual stretch operation.

In any event, the availability of product type machines for the Kawasaki facility still must be resolved.

In summary, it is now felt that the non-linear kerf problem may be primarily due to the manual stretch operation. It is quite possible that LED wafers expanded on a production machine such as seen at Kagoshima would result in satisfactory kerf linearity. Thus the residual problems would be adapting the Foton hoops to the process and reducing the distance between dice to 5 mils instead of 10.

An additional source of information that might be useful is as follows. The average dice geometry situation on the LED wafers received so far can be estimated very roughly as follows:

About 1/3 the area of these wafers had very linear kerfs and the Foton machine image recognition was not causing any noticeable connection in stepping from LED to LED. The machine was thus running at maximum rate.

Another 1/3 of the wafer area had a mild kerf non-linearity of less than 3 mils per LED spacing. In this area the Foton machine successfully compensated by adjusting wafer position with the video image detecting system. The machine operation and accuracy of positioning was not affected by this, but LED attach rate slowed down more or less due to the additional time required for the position correction.

The remaining 1/3 of a typical wafer had serious kerf deviations that were generally greater than 3 mils per LED position. Beyond this value the machine's optical recognition system cannot lock on the LED die and thus rejects each position and continues to step ahead looking for a lock on situation. This requires repeated manual intervention to use the LEDs in this area and is totally unsatisfactory.

RFR:eh

R. F. Redemske
R. F. Redemske



TELEDYNE

MEMORANDUM

NO: RFR:81-002

DATE: 25 Feb 1981

TO: FILE

FROM: R. F. Redemske

SUBJECT: Visit to Sanyo Electric Company Regarding LEDs for Displays,
23 and 28 January 1981

REFERENCE:

The purpose of the visit was to investigate Sanyo as a possible source for procurement of LED devices for the Litton DSD TDS-type modules and the Litton DCT Program.

About two years ago the Sanyo Green bulk emitting LEDs were evaluated for the TDS Program. The performance of the devices was excellent but Sanyo could not deliver them on a membrane in sawed wafer format, which was mandatory for automatic fabrication. The matter was then dropped. Sanyo representatives called a few months ago to inform us the LEDs were now available on membrane.

In the meantime Teledyne has become involved in bidding activity for DCT type display panels which require Red surface emitting LEDs. Sanyo is also a potential source for this type device.

The visit was arranged through the Sanyo local sales representatives, De Angelo, Rothman and Company, Inc. to tie in with a planned trip to Japan on other matters.

The visit schedule was as follows:

Friday, 23 January 1981:

Early airplane flight from Haneda Airport, Tokyo to Tottori, accompanied by Hiroshi Matsui, the Sanyo sales engineer who made all local arrangements, and Mr. Takamura of Teledyne Japan to help with translation problems. First stop was the Sanyo Tottori plant, known as Tottori Sanyo Electric Company, Ltd. This includes the engineering and development center for LED devices and both LED displays and liquid crystal displays. They also make the gallium phosphide material used in some LED devices and grow the single crystal boules of the material and finally slice it into wafers. Gallium arsenide wafers are brought in from an outside source. After diffusions and metallization the wafers are mounted on membrane, sawed and etched. They produce about 80 million LEDs per month. There is a small assembly shop with manual wire bonders but all production assembly of LED devices is done in a different plant in the town of Sayo.

After a plant tour of the Tottori facility there was an engineering discussion of the TDS application. They are somewhat familiar with the problems of placing a large number of LEDs on a substrate since they apparently cooperated with Sanyo Central Research in building flat television displays with 52,500 LEDs and multicolor displays. They were aware of the Teledyne TAC machine bought by Sanyo for that purpose.

One question discussed was why it was necessary to use the Foton type membrane mounting rings instead of the Sanyo standard rings. It was pointed out the Foton rings were only $\frac{1}{4}$ inch in depth while the Sanyo rings are about $\frac{3}{4}$ inch in depth and this would cause mechanical interference in the machine operation.

The next question discussed was the need for narrow and straight line kerf. The operation of the Foton machine and its pattern recognition system was described. A TDS module was also shown. The difference between their normal products and the TDS application is that the location accuracy of the LEDs would normally be in the range of 25 to 125 microns while the TDS application requires a location accuracy of ± 5 microns. This is due to the close spacing between Red-Green LEDs in a pair and because of the need for placing the light collecting overlay with 2048 lenses over the 2048 Red-Green pairs after complete assembly, including wire bonding. The Sanyo people now understand this completely.

A Teledyne question as to why the wafers could not be sawed all the way through to the membrane and not expanded was discussed. This would give a narrow kerf (perhaps 2 mils) and would guarantee absolute linearity of the kerf, thus assuring ideal conditions for maximum throughput of the Foton machine. However, Sanyo pointed out that this would eliminate the possibility of testing the LEDs optically and electrically in wafer form which is the optimum procedure. This is because there would be no available back contact to electrically operate the LEDs. The normal procedure is to saw almost all the way through but leave the gold backing on the wafer intact. Thus, before breaking, a connection can be made to the gold backing to provide a common back contact for all the LEDs on the wafer thus permitting electrical sample testing at that stage. Sanyo has a professional looking automatic test equipment for this purpose. Thus the subject of sawed through wafers was dropped.

The question of a specification for dice geometry characteristics on a membrane was raised. The following preliminary definition was presented:

1. Membrane support must be the Foton hoop.
2. Spacing between dice: Desirable - 3 mils
Maximum - 5 mils
3. Kerf deviation from linearity:

No more than 1 mil displacement per die position.

For 5 mil spacing the maximum angular deviation
would be expressed by:

$$\text{TAN } \theta = 1/15$$

Limit to how small the spacing can be will be determined by the ability to do a satisfactory etch in the Sanyo process.

The question as to production volume requirements was raised and the following estimates were given:

TDS Program

1981 - 3.5 million total (Red and Green)
1982 - 10 million total
5 years - 100 million total

DCT Program (Red only)

5 year forecast - 300 million

Sanyo stated that this volume was sufficient for them to be very interested. It was also pointed out that there was a requirement for two sources for these LEDs but that the split would not necessarily be 50 - 50. The source with the best price and of the best quality might get the bulk of the business. They understand this and accept it.

Final Action Items

Teledyne:

1. Supply 10 Foton hoops for experimental work at Sanyo.

Note: these were forwarded via the local sales rep,
Mr. DeAngelo, on 30 January 1981

2. Within a few weeks forward requests for bid for each of the LED types including latest specifications.

Sanyo:

1. Will conduct experimental work with Foton hoops and small kerfs. Expect to have answers in thirty days.

Saturday, 24 January 1981

Two hour drive from Tottori to Sayo, the location of device fabrication factory. Main feature was automatic fabrication of LED lamps. Die attach was totally automatic directly from expanded wafer on membrane. Rate was about 1 per second. Die placement was a two-step process. First pick die from membrane and place on intermediate platten. Fingers then center die on target point. Second arm picks up die and places on post in lamp structure. Epoxy die attach method. Machine had oscilloscope presentation similar to Foton with some form of pattern recognition. About six to eight machines in operation.

Wire bonding was automatic thermosonic running at about 1 wire per second. Very effective pattern recognition. Die placement error seemed about ± 3 mils but machine corrected for bond location very well. About six to eight machines in operation.

Both machines were designed and built at Sanyo central research facility. Automatic material handling, potting and testing was impressive.

At completion of visit returned to Tokyo.


Ralph F. Redemske

APPENDIX D

OPERATING INSTRUCTIONS
LED PANEL EXERCISER

[illegible]

TABLE OF CONTENTS

- 1.0 INTRODUCTION
- 2.0 TECHNICAL SPECIFICATIONS
- 3.0 INITIAL SET UP
- 4.0 LOCAL KEYBOARD OPERATION
- 5.0 RS-232C OPERATION

SIZE A	CODE IDENT NO. 16170	DRAWING NO. SK1034373
SCALE	REV	SHEET 2

1.0

INTRODUCTION

The Teledyne Display Exerciser provides a convenient means of exercising the Teledyne LED Display Panels. With the Exerciser alone, the LED panels PN's 2274705 and 2274715 can display ASCII Characters and Graphic Symbols. When supported by an off line computer via the built-in RS-232C Input, the Exerciser can display the same ASCII characters and graphic symbols, and in addition can selectively light any or all of the pixels in any of the three LED Colors (Red, Green, Amber).

2.0

TECHNICAL SPECIFICATIONS

Processor: 6502

Clock Frequency: 1 MHZ CLOCK

Read/Write Memory: 4K BYTES STATIC RAM

Read Only Memory: 2K BYTES "OPERATING SYSTEM"
2K BYTES " CHARACTER GENERATOR"

Display Format: "ASCII" - 4 Lines by 8 Character
"LITERAL" - Any location in the 32 by 64 DOT Matrix.

Character Set: 64 Displayable ASCII, 32 Graphic Symbols

Character Type: Upper Case 5 by 7 Dot Matrix within an 8 by 8 cell.

Graphics 8 by 8 Dot Matrix.

Cursor Type: Block

Cursor Controls: Up, Down, Backwards, Forward and Home

LED Drive: 25 MA at 1.5% Duty Cycle

3.0

INITIAL SET UP

The Display Exerciser requires only a 110 volt AC Power Source to operate. The system is intended to operate reliably in a typical office environment. Uncomfortably high temperatures coupled with low humidity may cause high voltage static discharged which can impair performance.

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Upon opening suitcase, remove the Display Fixture, Keyboard, and Cables. Plug in the (4) large ribbon cables into the panel at the locations J1, J2, J3, and J4. Plug the other end into the Display Fixture connectors J1, J2, J3 and J4, respectively. Connect the keyboard to the panel with the small ribbon cable. The system is now ready to operate.

NOTE: If the keyboard is not going to be used, it need not be connected to the Exerciser.

Place on LED panel into an appropriately sized plastic holder and insert the holder into the fixture. Orient the panel so that the "1" on the back of the panel is adjacent to the white dot of the fixture. Set the fixture lever to retain the panel/holder. Set the Exerciser "POWER" switch on.

NOTE: Do not remove or insert LED panels in the fixture when the Exerciser power is on.

4.0

LOCAL KEYBOARD OPERATION

Set the "INPUT" rocker switch to the "Keyboard" mode. The system is now ready to display any of the 64 available ASCII characters and any of the 32 Graphic Symbols, see Table I for a complete list of ASCII and Graphic Symbols. The local keyboard is also capable of using all of the control see Table II. In this mode of operation, the display is designed to display 32 characters. (4 lines with 8 characters per line). As each new character is entered on the keyboard, it appears to the immediate right of the last character entered. Each line is filled left to right. The lines are filled sequentially from top to bottom. When the panel is full, new characters are "written over" previous characters, starting at the top left. Note that all ASCII characters are upper-case and that graphic symbols are accessed using ASCII keys and the SHIFT key.

Control functions can be executed at any time by pressing the CTRL key and the appropriate ASCII key indicated in Table II. Control functions do not work if the SHIFT key is activated.

5.0

RS-232C OPERATION

Connect an off-line computer or terminal to the RS-232C connector of the Exerciser. See Figure 1 for details of this connection. Set the INPUT switch to "RS-232C". Set the BAUD RATE switch to the same rate as the computer or terminal.

The system is now ready to receive serial data. Signal levels should be within the requirements of the RS-232C specification. The data format must be: one start bit, eight data bits and two stop bits. Parity is not implemented. The first data bit received to be LSB.

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The Exerciser can be controlled via the RS-232C port in exactly the same way that the keyboard does. The data must be any of the seven bit ASCII codes shown in Table 1. The eight bit (MSB) must be "0".

In addition to the "ASCII" functions above, the Exerciser can also be controlled via the RS-232C port to light any pixel in the LED panel. This is termed the "Literal" mode of operation. The data for this function must be presented to the serial port as two sequential characters (bytes) with the MSB of each byte a "1". The remainder of the first byte gives the column address in binary form, and the remainder of the second byte gives the row address in binary form. Column zero is considered to be the left most column of the display; column 63 is the right most. Row zero is considered to be the top row, while the bottom row is thirty-one. (Note that this row designation is different from the row designation of the LED panel schematic).

As long as "Literal" data is presented as pairs of bytes, "Literal" and "ASCII" data can be intermixed. In fact, the "ASCII" control functions must be used to set the color of the pixels. For example, to turn off a pixel which is on, CTRL-Q is transmitted, followed by the "Literal" address of the pixel.

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TABLE I
SHIFTED
ASCII
CHAR.

ASCII CHAR.	BINARY	DEC.		BINARY	DEC.
A	01100001	97	■	01000001	65
B	01100010	98	■	01000010	66
C	01100011	99	□	01000011	67
D	01100100	100	□	01000100	68
E	01100101	101	□	01000101	69
F	01100110	102	□	01000110	70
G	01100111	103	■	01000111	71
H	01101000	104	□	01001000	72
I	01101001	105	■	01001001	73
J	01101010	106	□	01001010	74
K	01101011	107	■	01001011	75
L	01101100	108	□	01001100	76
M	01101101	109	■	01001101	77
N	01101110	110	□	01001110	78
O	01101111	111	■	01001111	79
P	01110000	112	□	01010000	80
Q	01110001	113	■	01010001	81
R	01110010	114	■	01010010	82
S	01110011	115	■	01010011	83

SIZE A	CODE IDENT NO. 16170	DRAWING NO. SK 1034373
SCALE	REV	SHEET 6

ASCII CHAR.	BINARY	DEC.	SHIFTED ASCII CHAR.	BINARY	DEC.
T	01110100	116	Ⓓ	01010100	84
U	01110101	117			
V	01110110	118			
W	01110111	119			
X	01111000	120			
Y	01111001	121			
Z	01111010	122			
[01011011	91	{	01111011	123
]	01011101	93	}	01111101	125
Ø	00110000	48			
1	00110001	49	:	00100001	33
2	00110010	50	"	00100010	34
3	00110011	51	#	00100011	35
4	00110100	52	\$	00100100	36
5	00110101	53	%	00100101	37
6	00110110	54	&	00100110	38
7	00110111	55	'	00100111	39
8	00111000	56	(00101000	40
9	00111001	57)	00101001	41

SIZE A	CODE IDENT NO. 16170	DRAWING NO. SK 1034373
DATE	REV	SHEET 7

ASCII CHAR.	BINARY	DEC.	SHIFTED ASCII CHAR.	BINARY	DEC.
:	00111010	58	*	00101010	42
:	00111011	59	+	00101011	43
,	00101100	44	<	00111100	60
-	00101101	45	=	00111101	61
.	00101110	46	>	00111110	62
/	00101111	47	?	00111111	63
\	01011100	92	@	01000000	64

SIZE	CODE IDENT NO.	DRAWING NO.
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		8

ASCII CHAR.	BINARY	DEC.	SHIFTED ASCII CHAR.	BINARY	DEC.
:	00111010	58	*	00101010	42
:	00111011	59	+	00101011	43
,	00101100	44	<	00111100	60
-	00101101	45	=	00111101	61
.	00101110	46	>	00111110	62
/	00101111	47	?	00111111	63
\	01011100	92	@	01000000	64

SIZE	CODE IDENT NO.	DRAWING NO.
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		8

TABLE II
CONTROL FUNCTIONS

CONTROL A	CHANGES DISPLAY COLOR TO AMBER
CONTROL G	CHANGES DISPLAY COLOR TO GREEN
CONTROL R	CHANGES DISPLAY COLOR TO RED
CONTROL Q	CHANGES DISPLAY COLOR TO "OFF"
NOTE: When the color is changed, previous entries are not affected. Only new entries have the new color.	
CONTROL P	TURNES ON DISPLAY CURSOR
CONTROL E	TURNES OFF DISPLAY CURSOR
CONTROL U	MOVES CURSOR UP ONE ROW
CONTROL D	MOVES CURSOR DOWN ONE ROW
CONTROL B	MOVES CURSOR ONE CHARACTER TO THE LEFT
CONTROL F	MOVES CURSOR ONE CHARACTER TO THE RIGHT
RETURN	HOMES THE CURSOR TO THE UPPER LEFT HAND CORNER
CONTROL C	COMPLETELY CLEARS THE DISPLAY
CONTROL Z	TURNES ON ALL THE LEDS IN DISPLAY IN THE CURRENT COLOR

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	<u>ASCII CHAR.</u>	<u>BINARY</u>	<u>DEC.</u>
Control	A	00000001	1
Control	G	00000111	7
Control	R	00010010	18
Control	P	00010000	16
Control	E	00000101	5
Control	Q	00010001	17
Control	U	00010101	21
Control	D	00000100	4
Control	B	00000010	2
Control	F	00000110	6
Control	C	00000011	3
Control	Z	00011010	26
Return		00001101	13

SIZE A	CODE IDENT NO. 16170	DRAWING NO. SK 1034373
SCALE	REV	SHEET 10

DB - 25P

RS-232C INPUT CONNECTOR

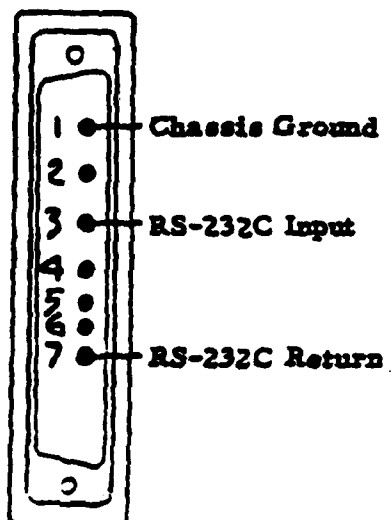


Figure 1

SIZE	CODE IDENT NO.	DRAWING NO.
A	16170	SKJ034373
DATE	REV	QUANTITY
		11

13 November 1979

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